

ACKNOWLEDGMENT

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CHAPTER 1: INTRODUCTION TO ELECTRONIC COMMUNICATIONS

TERMS	DEFINITIONS
Electronic Communication System	The fundamental purpose of _____ is to transfer information from one place to another.
Electronic Communication	It can be summarized as the transmission, reception, and processing of information between two or more locations using electronic circuits.
Analog signals	Are time-varying voltages or currents that are continuously changing such as sine and cosine waves.
Digital signals	This are voltages or currents that change in discrete steps or levels
Electromagnetic Induction	The process to transfer the information in the form of dots, dashes and space between a simple transmitter and receiver using transmission line consisting of a length of metallic wire.
Telephone	Alexander Graham Bell and Thomas A. Watson were the first to successfully transfer human conversation over a crude metallic-wire communications systems using this device.
Decibel (dB)	Is a logarithmic unit that can be used to measure ratio.
dBm	Is a unit of measurement used to indicate the ratio of a power level with respect to a fixed reference level (1mW).
Electronic Communications Time Line	
1830	American scientist and professor Joseph Henry transmitted the first practical electrical signal.
1837	Samuel Finley Breese Morse invented the telegraph.
1843	Alexander Bain invented the facsimile.
1861	Johann Phillip Reis completed the first nonworking telephone.
1864	James Clerk Maxwell released his paper “Dynamic Theory of the Electromagnetic Field” in which concludes that light, electricity and magnetism are related.

1865	Dr. Mahlon Loomis became the first person to communicate wireless through earth's atmosphere.
1866	First transatlantic telegraph cable was installed.
1876:	Alexander Graham Bell and Thomas Watson Invented the telephone.
1877	Thomas Alva Edison invents the phonograph.
1880	Heinrich Hertz discovers electromagnetic waves.
1887	Heinrich Hertz discovers radio waves. Marchese Guglielmo Marconi demonstrates wireless radio wave propagation.
1888	Heinrich Hertz detects and produces radio waves. Heinrich Hertz conclusively proved Maxwell's prediction that electricity can travel in waves through earth's atmosphere.
1894	Marchese Guglielmo Marconi builds his first radio equipment, a device that rings a bell from 30 ft. away.
1895	Marchese Guglielmo Marconi discovered ground wave propagation.
1898	Marchese Guglielmo Marconi established the first radio link between England and France.
1900	American Scientist Reginald A. Fessenden the world's first radio broadcast using continuous waves.
1901	Marchese Guglielmo Marconi transmits telegraphic radio messages from Cornwall, to Newfoundland. Reginald A. Fessenden transmits the World's first radio broadcast using continuous waves. First successful transatlantic transmission of radio signal.
1903	Valdemar Poulsen patents an arc transmission that generates continuous wave transmission 100-kHz signal that is receivable 150 miles away.
1904	First radio transmission of music at Graz, Austria.
1905	Marchese Guglielmo Marconi invents the directional radio antenna.
1906	Reginald A. Fessenden invents amplitude modulation (AM). First radio program of voice and music broadcasted in the United States

	by Reginald Fessenden. Lee DeForest invents triode (three-electrode) vacuum tube.
1907	Reginald Fessenden invents a high- frequency Electric generator that produces radio waves with a frequency of 100 kHz
1908	General Electric develops a 100-kHz, 2-kW alternator for radio communications.
1910	The Radio Act of 1910 is the first concurrence of government regulation of radio technology and services.
1912	The Radio Act of 1912 in the United States brought order to the radio bands by requiring station and operators licenses and assigning blocks of the frequency spectrum to the existing users.
1913	The cascade-tuning radio receiver and the heterodyne receiver are introduced.
1914	Major Edwin Armstrong develops the superheterodyne radio receiver
1915	Vacuum-tube radio transmitters introduced.
1919	Shortwave radio is developed.
1920	Radio Station KDKA broadcasts the first regular licensed radio transmission out of Pittsburgh, Pennsylvania.
1921	Radio Corporation of America (RCA) begins operating Radio Central on Long Island. The American Radio League establishes contact via shortwave radio with Paul Godley in Scotland, proving that shortwave radio can be used for long distance communications.
1923	Vladimir Zworykin invents and demonstrates television.
1927	A temporary five- member Federal Radio Commission agency was created in the United States.
1928	Radio station WRNY in New York City begins broadcasting television shows
1931	Major Edwin Armstrong patents wide- band frequency modulation (FM).
1934	Federal Communications Commission (FCC) created to regulate telephone, radio, and television broadcasting.

1935	Commercial FM radio broadcasting begins with monophonic transmission.
1937	Alec H. Reeves invents binary coded pulse-code modulation. (PCM)
1939	National Broadcasting Company (NBC) demonstrates television broadcasting. First use of two-way radio communications using walkie-talkies.
1941	Columbia University Radio Club opens the first regularly scheduled FM radio station.
1945	Television is born. FM is moved from its original home of 42 MHz to 50 MHz to 88 MHz to 108 Mhz
1946	The American Telephone and Telegraph Company (AT&T) inaugurated the first mobile telephone system for the public called MTS
1948	John Von Neumann created the first store program electronic digital computer. Bell Telephone Laboratories unveiled the transistor, a joint venture of scientist William Shockley, John Bardeen and Walter Brattain.
1951	First transcontinental microwave system began operation.
1952	Sony Corporation offers a miniature transistor radio, one of the first massproduced consumer AM/FM radios.
1953	RCA and MBC broadcast first color television transmission.
1954	The number of radio stations in the world exceeds the number of newspapers printed daily. Texas Instruments becomes the first company to commercially produce silicon transistors.
1956	First transatlantic telephone cable systems began carrying calls.
1957	Russia launches the world's first satellite. (Sputnik)
1958	Kilby and Noyce develop first integrated circuits. NASA launched the United States first satellite
1961	FCC approves FM stereo broadcasting, which spurs the development of FM. Citizens band (CB) radio first used.

1962	U.S. radio stations begin broadcasting stereophonic sound.
1963	T1 (transmission 1) digital carrier systems introduced.
1965	First commercial communications satellite launched.
1970	High-definition television (HDTV) introduced in Japan.
1977	First commercial use of optical fiber cables.
1983	Cellular telephone networks introduced in the United States.
1999	HDTV standards implemented in the United States.
1999	Digital Television (DTV) transmission began in the United States.
Attenuation	A power loss is sometimes called.
Transmitter	A collection of one or more electronic devices or circuits that converts the original source information to a form more suitable for transmission over a particular transmission medium.
Transmission Medium	Provides a means of transporting signals between a transmitter and a receiver.
System Noise	Is any unwanted electrical signals that interfere with the information signal
Receiver	A collection of electronic devices and circuits that accepts the transmitted signals from the transmission medium and then converts those signals back to their original form.
Carrier	Because it is often impractical to propagate information signals over standard transmission media, it is often necessary to modulate the source information onto a higher-frequency analog signal called a _____.
Modulation	The process of changing one or more properties of the analog carrier in proportion with the information signal.
Analog Communication System	A system in which energy is transmitted and received in analog form (a continuously varying signals such as a sine wave).

Digital Communications	It is the term covers a broad range of communications technique, including digital transmission and digital radio.
Digital Transmission	A true digital system where digital pulses (discrete levels such as +5V and ground) are transferred between two or more points in a communications system.
Digital radio	The transmittal of digitally modulated analog carriers between two or more points in a communications system.
Amplitude Modulation (AM)	A modulation technique where the information signal is analog and the amplitude (V) of the carrier is varied proportional to the information signal.
Frequency Modulation (FM)	A modulation technique where the information signal is analog and the frequency (f) of the carrier is varied proportional to the information signal.
Phase Modulation	A modulation technique where the information signal is analog and the phase (θ) of the carrier is varied proportional to the information signal.
Amplitude Shift Keying (ASK)	A modulation technique where the information signal is digital and that amplitude (V) of the carrier is varied proportional to the information signal.
Frequency Shift Keying (FSK)	A modulation technique where the information signal is digital and the frequency (f) of the carrier is varied proportional to the information signal.
Phase Shift Keying (PSK)	A modulation technique where the information signal is digital and the phase (θ) of the carrier is varied proportional to the information signal.
Quadrature Amplitude Modulation (QAM)	A modulation technique where both the amplitude and the phase of the carrier are varied proportional to the information signal.
Modulator	Modulation is performed in a transmitter by a circuit called?
Demodulation	The reverse process of modulation and converts the modulated carrier back to the original information.
Demodulator	Demodulation is performed in a receiver by a circuit called?
2 Reasons why modulation is necessary in electronic communications :	

<ol style="list-style-type: none"> 1. It is extremely difficult to radiate low-frequency signals from an antenna in the form of electromagnetic energy. 2. Information signals often occupy the same frequency band and, if signals from two or more sources are transmitted at the same time, they would interfere with each other. 	
Channel	A specific band of frequencies allocated a particular service.
Frequency Translation	Process of converting a frequency or band of frequencies to another location in the total frequency spectrum.
Stations	The purpose of an electronic communications system is to communicate information between two or more locations commonly called?
Frequency	The number of times a periodic motion, such as a sine wave of voltage or current, occurs in a given period of time.
Cycle	Each complete alternation of the waveform.
Subsections or bands	Electromagnetic Frequency Spectrum is divided into _____ with each band having a different boundary.
International Telecommunications Union (ITU)	Is an international agency in control of allocating frequencies and services within the overall frequency spectrum.
Federal Communications Commission (FCC)	In the United States, assigns frequencies and communications services for free-space radio propagation.
<p style="text-align: center;">Electromagnetic Frequency Spectrum</p> <p style="text-align: center;">Frequency (Hz)</p>	

International Telecommunication Union (ITU) Designation		
Band Number	Frequency Range	Designation
2	30 Hz - 300 Hz	ELF (Extremely Low Frequency)
3	0.3 KHz - 3 KHz	VF (Voice Frequency)
4	3 KHz - 30 KHz	VLF (Very Low Frequency)
5	30 KHz - 300 KHz	LF (Low Frequency)
6	0.3 MHz - 3 MHz	MF (Medium Frequency)
7	3 MHz - 30MHz	HF (High Frequency)
8	30 MHz – 300 MHz	VHF (Very High Frequency)
9	300 MHz – 3 GHz	UHF (Ultra High Frequency)
10	3 GHz – 30 GHz	SHF (Super High Frequency)
11	30 GHz – 300 GHz	EHF (Extremely High Frequency)
12	0.3 THz – 3 THz	Infrared Light
13	3 THz – 30 THz	Infrared Light
14	30 THz – 300 THz	Infrared Light
15	0.3 PHz – 3 PHz	Visible Light
16	3 PHz – 30 PHz	Ultraviolet Light
17	30 PHz – 300 PHz	X-Rays
18	0.3 EHz – 3 EHz	Gamma Rays
19	3 EHz – 30 EHz	Cosmic Rays
Extremely Low Frequencies (ELF)	Are signals in the 30Hz to 300Hz range and include ac power distribution signals (60Hz) and low frequency telemetry signals.	
Voice Frequencies (VF)	Are signals in the 300Hz to 3000Hz range and include frequencies generally associated with human speech.	
Very Low Frequencies (VLF)	Are signals in the 3kHz to 30kHz range which include the upper end of the human hearing range.	
Low Frequencies (LF)	Are signals in the 30kHz to 300kHz range and are used primarily for marine and aeronautical navigation.	
Medium Frequencies (MF)	Are signals in the 300kHz to 3MHz range and are used primarily for commercial AM radio broadcasting (535kHz-1605kHz).	
High Frequencies (HF)	Are signals in the 3MHz to 30MHz range and are often referred to as short waves. Used for most two-way radio communications.	
Very High Frequencies	Are signals in the 30MHz to 300MHz range and are used for mobile radio, marine and aeronautical communications,	

(VHF)	commercial FM broadcasting (88 to 108MHz) and commercial TV broadcasting of Ch 2 to 13 (54MHz to 216MHz).
Ultrahigh Frequencies (UHF)	Are signals in the 300MHz to 3GHz range and are used by commercial television broadcasting of channels 14 to 83, land mobile communications services, cellular telephones, certain radar and navigation systems, and microwave and satellite radio systems.
Super High Frequencies (SHF)	Are signals in the 3GHz to 30GHz range and include the majority of the frequencies used for microwave and satellite radio communications systems.
Extremely High Frequencies (EHF)	Are signals in the 30GHz to 300GHz range and are seldom used for radio communications except in very sophisticated, expensive, and specialized applications.
Infrared	Are signals in the 0.3THz to 300THz range and are not generally referred to as radio waves. Used in heat seeking guidance systems, electronic photography, and astronomy.
Visible Light	Includes electromagnetic frequencies that fall within the visible range of humans (0.3PHz to 3PHz).
Light-wave Communications	Used for optical fiber systems.
Wavelength	The length that one cycle of an electromagnetic wave occupies in space (i.e., the distance between similar points in a repetitive wave).
Emission Classifications	Radio transmitter classifications according to bandwidth, modulation scheme, and type of information.

Federal Communications Commission (FCC) Emission Designation

- The first symbol is a letter that designates the type of modulation of the main carrier.
- The second symbol is a number that identifies the type of emission.
- The third symbol is another letter that describes the type of information being transmitted.

SYMBOLS	LETTERS	TYPE OF MODULATION
First	Unmodulated	

	N	Unmodulated Carrier
	Amplitude Modulation	
	A	Double-Sideband Full Carrier (DSBFC)
	B	Independent Sideband Full Carrier (ISBFC)
	C	Vestigial Sideband Full Carrier (VSB)
	H	Single-Sideband Full Carrier (SSBFC)
	J	Single-Sideband Suppressed Carrier (SSBSC)
	R	Single-Sideband Reduced Carrier (SSBRC)
	Angle Modulation	
	F	Frequency Modulation (Direct FM)
	G	Phase Modulation (Indirect Modulation)
	D	AM and FM Simultaneously or Sequenced
	Phase Modulation	
	K	Pulse Amplitude Modulation (PAM)
	L	Pulse Width Modulation (PWM)
	M	Pulse Position Modulation (PPM)
	P	Unmodulated Pulses (Binary Data)
	Q	Angle Modulation During Pulses
	V	Any Combination of Pulse-Modulation Category
	W	Any Combination of two or more of the above forms of modulation
	X	Cases Otherwise Covered
Second	0	No Modulating Signal
	1	Digitally Keyed Carrier
	2	Digitally Keyed Tone
	3	Analog (sound or video)
	7	Two or More Digital Channel
	8	Two or More Analog Channel
	9	Analog or Digital
Third	A	Telegraphy, Manual
	B	Telegraphy, Automatic (teletype)
	C	Facsimile
	D	Data, Telemetry
	E	Telephony (Sound Broadcasting)
	F	Television (Video Broadcasting)
	N	No Information Transmitted
	W	Any Combination of Second letter
Noise and Bandwidth		The two most significant limitations on the performance of a communications system are?

Bandwidth	It is the range of frequency over which the operation of a system is guaranteed satisfactory.
Passband	The bandwidth of a communications channel is the difference between the highest and lowest frequencies that the channel will allow to pass through it.
Information Theory	A highly theoretical study of the efficient use of bandwidth to propagate information through electronic communications systems.
Information Capacity	The measure of how much information can be propagated through a communications system and is a function of bandwidth and transmission time.
Binary Digit / Bit	The most basic digital symbol used to represent information.
Bit Rate	The number of bits transmitted during one second and is expressed in bits per second (bps).
Hartley's Law $I \propto B \times t$	In 1928, R. Hartley of Bell Telephone Laboratories developed a useful relationship among bandwidth, transmission time, and information capacity.
Shannon limit for information capacity $I = B \log_2 \left[1 + \frac{S}{N} \right]$ <p>or</p> $I = 3.32 B \log_2 \left[1 + \frac{S}{N} \right]$ <p>I = Information Capacity B = Bandwidth $\frac{S}{N}$ = Signal to noise ratio</p>	In 1948, mathematician Claude E. Shannon published a paper in the Bell System Technical Journal relating the information capacity of a communications channel to bandwidth and signal-to-noise ratio.
Electrical Noise	Any undesirable electrical energy that falls within the passband of the signal.
Uncorrelated Noise	Noise present regardless of whether there is a signal present or not.
External Noise	Noise that is generated outside the device or circuit.

Atmospheric Noise	Noise that is naturally occurring electrical disturbances that originate within Earth's atmosphere.
Static Electricity	Atmospheric noise is commonly called?
Extraterrestrial Noise	Noise consists of electrical signals that originate from outside Earth's atmosphere.
Deep-Space Noise	Extraterrestrial noise is sometimes called?
Solar Noise	Noise generated directly from the sun's heat.
Cosmic Noise	Noise sources that are continuously distributed throughout the galaxies.
Black-body Noise	Cosmic Noise is often called?
Man-made Noise	Noise that is produced by mankind.
Industrial Noise	Man-made noise is most intense in the more densely populated metropolitan and industrial areas and therefore it is sometimes called?
Internal Noise	Electrical interference generated within a device or circuit.
Shot Noise	Noise caused by the random arrival of carriers (holes and electrons) at the output element of an electronic device.
Transit-time Noise	Any modification to a stream of carriers as they pass from the input to the output of a device produces irregular, random variations.
Thermal Noise	Associated with the rapid and random movement of electrons within a conductor due to thermal agitation.
THERMAL AGITATION HAS SEVERAL NAMES, INCLUDING : <ul style="list-style-type: none"> • Thermal Noise, because it is temperature dependent; • Brownian Noise, after its discoverer; • Johnson Noise, after the man who related Brownian particle movement of electron movement; • White Noise, because the random movement is at all frequencies; 	
White Noise Source	A thermal noise source is sometimes called?

<table><tr><td colspan="2">Electrical Noise Source Summary</td></tr><tr><td colspan="2">Correlated Noise (Internal)</td></tr><tr><td colspan="2">Nonlinear Distortion</td></tr><tr><td colspan="2">Harmonic Distortion</td></tr><tr><td colspan="2">Intermodulation Distortion</td></tr><tr><td colspan="2">Uncorrelated Noise</td></tr><tr><td colspan="2">External</td></tr><tr><td colspan="2">Atmospheric</td></tr><tr><td colspan="2">Extraterrestrial</td></tr><tr><td colspan="2">Solar</td></tr><tr><td colspan="2">Cosmic</td></tr><tr><td colspan="2">Man-made</td></tr><tr><td colspan="2">Impulse</td></tr><tr><td colspan="2">Interference</td></tr><tr><td colspan="2">Internal</td></tr><tr><td colspan="2">Thermal</td></tr><tr><td colspan="2">Shot</td></tr><tr><td colspan="2">Transient Time</td></tr></table>		Electrical Noise Source Summary		Correlated Noise (Internal)		Nonlinear Distortion		Harmonic Distortion		Intermodulation Distortion		Uncorrelated Noise		External		Atmospheric		Extraterrestrial		Solar		Cosmic		Man-made		Impulse		Interference		Internal		Thermal		Shot		Transient Time	
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Noise Power N = KTB N = noise factor B = bandwidth (Hz) K = Boltzmann’s proportionality constant T = absolute temp.(Kelvin)	Johnson proved that thermal noise power is proportional to the product of bandwidth and temperature.																																				
Correlated Noise	A form of internal noise that is correlated (mutually related) to the signal and cannot be present in a circuit unless there is a signal. “No signal, No noise! “																																				
Harmonic	Is an integral multiple of the fundamental frequency.																																				
Harmonic Distortion	Occurs when unwanted harmonics of a signal are produced through nonlinear amplification (nonlinear mixing).																																				
Amplitude Distortion	Another name for harmonic distortion.																																				
Inter-modulation Distortion	The generation of unwanted sum and difference frequencies produced when two or more signals mix in a nonlinear device.																																				
First Harmonic	The original signal and also called the fundamental frequency.																																				
Second Harmonic	A frequency two times the original signal frequency.																																				

Third Harmonic	A frequency three times the original signal frequency.
Impulse Noise	Characterized by high-amplitude peaks of short duration in the total noise spectrum.
Interference	A form of external noise and as the name implies it means to disturb or detract from.
Electrical interference	Noise produced when information signals from one source produce frequencies that fall outside their allocated bandwidth and interfere with information signals from another source.
Signal-to-Noise Power Ratio (S/N) $\frac{S}{N} = \frac{P_s}{P_n}$	The ratio of the signal power level to the noise power level.
Noise Factor (F) and Noise Figure (NF)	Figures of merit used to indicate how much the signal- to-noise ratio deteriorates as a signal passes through a circuit or series of circuits
FORMULA OF NOISE FACTOR $F = \frac{\text{Input signal-to-noise power ratio}}{\text{Output signal-to-noise power ratio}} \quad (\text{unitless ratio})$	
FORMULA FOR NOISE FIGURE NF (dB) = 10 log F	
Friiss Formula	It is used to calculate the total noise factor of several cascaded amplifiers.
Friiss Formula $F_T = F_1 + \frac{F_2 - 1}{A_1} + \frac{F_3 - 1}{A_1 A_2} + \frac{F_n - 1}{A_1 A_2 \dots A_n}$	

<p>Note that to use the Friiss formula, the noise figure must be converted to noise factor. The total noise figure is simply</p> $NF_T(\text{dB}) = 10 \log F_T$	
<p>Equivalent Noise Temperature (T_e)</p> $T_e = T (F - 1)$	<p>A convenient parameter often used rather than noise figure in low noise, sophisticated VHF, UHF, microwave, and satellite radio receivers. It indicates the reduction in the signal-to-noise ratio a signal undergoes as it propagates through a receiver.</p>

CHAPTER 2: SIGNAL ANALYSIS AND MIXING

TERMS	DEFINITIONS
Analog Signals	The amplitude changes continuously with respect to time with no breaks and discontinuities.
Digital Signals	The amplitude maintains a constant level for a prescribed period of time and then it changes to another level.
Quaternary Digital Signals	A four-level digital signal.
Electrical Signals	Are voltage- or current-time variations that can be represented by a series of sine or cosine waves.
Signal Analysis	Is the mathematical analysis of the frequency, bandwidth and voltage level of a signal.
Periodic Wave	A wave that repeats at a uniform rate.

Time Domain	Is a representation of signal with respect to time.
Signal Waveform	Is an amplitude-versus-time representation of the signal.
Frequency Domain	Is a description of signal with respect to its frequency.
Nonsinusoidal, Complex Wave	Is any repetitive waveform that is comprised of more than one harmonically related sine or cosine wave.
Fourier Series	Used to analyze a complex periodic wave, developed in 1826 by the French physicist and mathematician Baron Jean Fourier.
Fourier Analysis	Is a mathematical tool that allows us to move back and forth between the time and frequency domains.
Duty Cycle	Is the ratio of the active time pulse to the period of the waveform.
Harmonic	Is an integral multiple of the fundamental frequency.
Fundamental Frequency	Is the first harmonic and equal to the frequency of the waveform.
Wave Symmetry	Describes the symmetry of the waveform in the time domain.
Even Symmetry	A symmetric periodic voltage waveform that is said to have axes or mirrors.
Odd Symmetry	A symmetric periodic voltage waveform that is said to have point or skew.
Half-Wave Symmetry	A symmetric periodic voltage waveform which has a first half cycle that repeats itself except with the opposite sign for the second half cycle.

Frequency Spectrum	Consists of all the frequencies contained in the waveform and their respective amplitudes plotted in the frequency domain.
Bandwidth	Is the range of frequencies contained in the spectrum.
Rectangular Pulses	Used to analyze electronics communications circuits.
Electrical Power	Is the rate at which energy is dissipated, delivered, or used and is a function of the square of the voltage or current.
Bandlimiting	Changing the signal's frequency content and, thus, the shape of its waveform.
Mixing	Is the process of combining two or more signals and is an essential process in electronic communications.
Linear Summing	Occurs when two or more signals combine in a linear device, such as a passive network or a small-amplifier.
Nonlinear Mixing	Occurs when two or more signals are combined in a nonlinear device such as diode or large-signal amplifier.
Harmonic Distortion	It is when the generation of harmonics is undesired in nonlinear amplification of a single frequency.
Frequency Multiplication	It is when the generation of harmonics is undesired in nonlinear amplification of a single frequency.
Intermodulation Distortion	It is when the produced cross-products are undesired when two or more frequencies mix in a nonlinear device.
Modulation	It is when the produced cross-products are undesired when two or

	more frequencies mix in a nonlinear device.
Characteristics of a Repetitive Rectangular Wave	<ul style="list-style-type: none"> • The dc component is equal to the pulse amplitude times the duty cycle. • There are 0-V components at frequency $1/T$ hertz and all integer multiples of that frequency providing $T = nT$, where $n =$ any odd integer. • The amplitude-versus-frequency time envelope of the spectrum components take on the shape of a damped sine wave in which all spectrum components in odd-numbered lobes are positive and all spectrum components in even-numbered lobes are negative.
Single-Frequency Voltage and Current Waveform	$v(t) = V \sin(2\pi ft + \theta) \text{ or } v(t) = V \cos(2\pi ft + \theta)$ $i(t) = I \sin(2\pi ft + \theta) \text{ or } i(t) = I \cos(2\pi ft + \theta)$ <p>Where:</p> <p>$v(t)$ = time-varying voltage sine wave $i(t)$ = time-varying current sine wave V = peak voltage (Volts) f = frequency (Hertz) θ = phase shift (Radians) I = peak current (Amperes) $2\pi f$ = angular velocity (Radians per Second)</p>
Fourier Series Equation	$f(t) = A_0 + A_1 \cos \alpha + A_2 \cos 2\alpha + A_3 \cos 3\alpha + \dots A_n \cos n\alpha$ $+ A_0 + B_1 \sin \beta + B_2 \sin 2\beta + B_3 \sin 3\beta + \dots B_n \sin n\beta$ <p>Where:</p> <p>$\alpha = \beta$</p>
Harmonic Equation	$f(t) = \text{dc} + \text{fundamental} + 2^{\text{nd}} \text{ harmonic} + 3^{\text{rd}} \text{ harmonic} + \dots \text{nth harmonic}$
Even Symmetry Functions	Even Functions : $f(t) = f(-t)$
Odd Symmetry Functions	Odd Functions : $f(t) = -f(-t)$
Half-Wave Symmetry Functions	Half-Wave Functions : $f(t) = -f(T + t) / 2$

Duty Cycle	$DC = (T / T)$
Duty Cycle Percent	$\%DC = (T / T) \times 100$ Where: DC = duty cycle as a decimal %DC = duty cycle as a percent T = pulse width of the rectangle wave (seconds) T = period of the rectangular wave (second)
Fourier Series for Rectangular Voltage Waveform	$v(t) = (V_T / T) + (2VT / T)[(\sin x / x)(\cos \omega t) + (\sin 2x / 2x)(\cos 2\omega t) + \dots + (\sin nx / nx)(\cos n\omega t)]$ Where: v(t) = time-varying voltage wave T = pulse width of the rectangular wave (seconds) T = period of the rectangular wave (seconds) $x = \pi (T / T)$ n = nth harmonic and can be any positive integer value V = peak pulse amplitude (volts)
Rectangular Waveform with 0 Hz (dc) Component	$V_0 = (V)(T / T)$ $V_0 = (V)(DC)$ Where: V ₀ = dc voltage (volts) DC = duty cycle as a decimal T = pulse of the rectangular wave (seconds) T = period of the rectangular wave (seconds)
Amplitude of the nth Harmonic	$V_n = (2VT / T)(\sin nx / nx)$ $V_n = (2VT / T)[(\sin(n\pi T / T)) / (n\pi T / T)]$

	<p>Where:</p> <p>V_n = peak amplitude of the nth harmonic (volts)</p> <p>n = nth harmonic (any positive integer)</p> <p>$\pi = 3.14159$ radians</p> <p>V = peak amplitude of the rectangular wave (volts)</p> <p>T = pulse width of the wave (seconds)</p> <p>T = period of the rectangular wave (seconds)</p>
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CHAPTER 3: OSCILLATORS, PHASE-LOCKED LOOPS, AND FREQUENCY SYNTHESIZERS

TERMS	DEFINITIONS
Oscillate	Is to fluctuate between two states or conditions, to vibrate or change.
Oscillating	Is the act of fluctuating from one state to another state.
Oscillator	Is a device that produces electronic oscillations.
Electrical Oscillation	Is a repetitive change in a voltage or current waveform.
Self-sustaining Oscillators	Also known as free-running oscillators, wherein the changes in waveform are continuous and repetitive, in other words, they occur a periodic wave.
Not Self-sustaining Oscillators	Also known as triggered or one-shot oscillators, are those who requires an external input signal or trigger to produce a change in the output waveform.

Feedback Oscillator	Is an amplifier with a feedback loop. It generates an ac output signal of which a small portion is fed back to the input, where it is amplified.
Barkhausen Criterion	States that, for a feedback circuit to sustain oscillations, the net voltage gain around the feedback loop must be unity or greater, and the net phase shift around the loop must be a positive integer multiple of 360° .
Four Requirements for Feedback Oscillator to Work	<ul style="list-style-type: none"> • Amplification – an oscillator circuit must include at least one active device and be capable of voltage amplification. • Positive Feedback – an oscillator circuit must have a complete path for a portion of the output signal to be returned to the input. • Frequency-determining components – an oscillator circuit must have frequency-determining components such as resistors, capacitors, inductors, or crystal to all the frequency of operation to be set or changed. • Power Source – an oscillator circuit must have a source of electrical energy, such as a dc power supply.
Regenerative Feedback	Also called as positive feedback, where its phase aids the oscillation process.
Degenerative Feedback	Also called as negative feedback and supplies a feedback signal that inhibits oscillations from occurring.
Open-loop Voltage Gain	Is the voltage gain of the amplifier with the feedback path open circuited.
Closed-loop Voltage Gain	Is the overall voltage gain of the complete circuit with the feedback loop closed and is always less than the open-loop voltage gain.
Feedback Ratio	The transfer function of the feedback network. For a passive feedback network, the feedback ratio is always less than 1.
Wien-bridge Oscillator	Is an unturned RC phase shift oscillator that uses both positive and

	negative feedback. It is a relatively stable, low-frequency oscillator circuit that is easily tuned and commonly used in signal generators to produce frequencies between 5 Hz and 1 MHz.
Lead-lag Network	Is a reactive voltage divider in which the input voltage is divided between Z1 (the series combination of R1 and C1) and Z2 (the parallel combination of R2 and C2). A frequency selective network.
Automatic Gain Control (AGC)	Is a network added in a circuit to compensate the imbalances in the bridge (Wien) and variations in the component values due to heat.
LC Oscillator	Is an oscillator circuit that utilizes tuned LC tank circuits for the frequency-determining components. Tank circuit operation involves an exchange of energy between kinetic and potential.
Hartley Oscillator	Is an oscillator circuit comprising of two inductors connected in series and capacitor that is connected in parallel with the two inductors.
Colpitts Oscillator	Is an oscillator circuit comprising of two capacitors connected in series and an inductor that is connected in parallel with the two capacitors.
Clapp Oscillator	Is an identical circuit of Colpitts oscillator with the addition of a small capacitor placed in series with the first inductor.
Frequency Stability	Is the ability to remain at a fixed frequency and is of primary importance in the communications systems.
Short-term Stability	Affected predominantly by fluctuations in dc operating voltages.
Long-term Stability	Is a function of component aging and changes in the ambient temperature and humidity.
Crystal Oscillators	Are feedback oscillator circuits in which the LC tank circuit is replaced with a crystal for the frequency-determining component.

Crystallography	Is the study of the form, structure, properties, and classification of crystals.
Piezoelectric Effect	Occurs when oscillating mechanical stresses applied across a crystal lattice structure generate electrical oscillations and vice versa.
Natural crystal substances that exhibits piezoelectric properties	<ul style="list-style-type: none"> • Quartz • Rochelle Salt • Tourmaline
Positive Temperature Coefficient	If the direction of the frequency change is the same as the temperature change.
Negative Temperature Coefficient	If the change in frequency is in the direction opposite to the temperature change.
Crystal Oscillator Module	Consists of a crystal-controlled oscillator and a voltage-variable component such as a varactor diode.
Voltage-controlled Oscillator	Is a free-running oscillator with a stable frequency of oscillation that depends on an external timing capacitance, timing resistance, and control voltage.
Monolithic Voltage-controlled Oscillators	<p>Ex: XR-2207</p> <p>An integrated circuit featuring excellent frequency stability and a wide tuning range.</p>
Monolithic Precision Oscillators	Ex: XR-2209

	A monolithic variable-frequency oscillator circuit featuring excellent temperature stability and a wide linear sweep range.
Phase-locked Loop	Is an extremely versatile circuit used extensively in modern electronic communications systems for performing a wide variety of functions, including modulation, demodulation, signal processing, carrier and clock recovery, frequency generation, frequency synthesis, and a wide variety of other electronic communications applications.
Phase Comparator	Sometimes called a phase detector, is a nonlinear device with two input signals: an external input frequency and the VCO input signal.
3 Operating States of PLL	<ul style="list-style-type: none"> • Free running • Capture • Lock
Free Running State	Either there is no external input frequency or the feedback loop is open.
Capture State	There must be an external input signal, and the feedback loop must be complete.
Lock State	The VCO output frequency is locked onto (equal to) the frequency of the external input signal.
Acquisition Time or Pull-in Time	The time required to achieve lock.
Capture Range	Is defined as the band of frequencies centered around the VCO natural frequency where the PLL can initially establish or acquire frequency lock with an external input signal from an unlocked condition.
Lock Range	Is defined as the band of frequencies centered on the VCO's natural frequency over which a PLL can maintain frequency lock with an external input signal. Also known as tracking range.

Hold-in Range	Is the lock range expressed as a peak value.
Phase Detector	Sometimes called as a phase comparator, is a nonlinear device with two input signals: an external input frequency and the VCO output signal.
Loop Gain for PLL	Is simply the product of the individual gains or transfer functions around the loop.
Digital PLL	Used to track digital pulses rather than analog signals, such as in clock recovery circuits.
Synthesize	Means to form an entity by combining parts or elements.
Frequency Synthesizer	Used to generate many output frequencies through addition, subtraction, multiplication, and division of a smaller number of fixed frequency sources.
Multiple-crystal Frequency Synthesis	Uses nonlinear mixing and filtering to produce 128 different frequencies from 20 crystals and two oscillator modules.
Resolution	The minimum frequency separation between output frequencies for a synthesizer.
Single-crystal Frequency Synthesis	Uses frequency addition, subtraction, multiplication, and division to generate frequencies (in 1 Hz steps) from 1 Hz to 999,999 Hz.
Frequency of Oscillation (f_O) for RC Oscillators	$f_O = 1 / 2\pi RC$ <p>Where: $R = R_1 = R_2$ $C = C_1 = C_2$</p>
Frequency of Oscillation (f_O) for Hartley Oscillators	$f_O = 1 / 2\pi\sqrt{LC}$ <p>Where: $L = L_{1a} + L_{1b}$</p>

	$C = C_1$
Frequency of Oscillation (f_o) for Colpitts Oscillators	$f_o = 1 / 2\pi\sqrt{LC}$ Where: $L = L_1$ $C = (C_{1a}C_{1b}) / (C_{1a} + C_{1b})$
Change of Frequency in Crystal	$\Delta f = k (f_n \Delta C)$ Where: Δf = change in frequency (Hertz) k = temperature coefficient (Hz/MHz/°C) f_n = natural crystal frequency (Megahertz) ΔC = change in temperature (degrees Celsius)
Frequency Operation of Crystal	$f_o = f_n + \Delta f$
Series Resonant Frequency of Quartz Crystal	$f_1 = 1 / 2\pi\sqrt{LC_1}$
Parallel Resonant Frequency of Quartz Crystal	$f_1 = 1 / 2\pi\sqrt{LC}$ Where: C = the series combination of C_1 and C_2
Capacitance of Varactor Diode	$C_d = C / \sqrt{(1 + 2 V_r)}$ Where: C = diode capacitance with 0 V reverse bias (Farads) $ V_r $ = magnitude of diode reverse-bias voltage (Volts) C_d = reverse-biased diode capacitance (Farads)
Formula for Determining Two	$f_1 = 1 / R_1 C$

Frequencies of Operation of a Monolithic Function Generator	$f_2 = 1 / R_2 C$ Where: R_1 = resistor connected to pin 7 R_2 = resistor connected to pin 8
Frequency of Oscillation Related to VC	$f = (1 / RC)(1 + (R / R_C)([1 - V_C] / 3)) \quad (\text{Hz})$ Where: V_C = Control Voltage
Voltage-to-frequency Conversion Gain K	$K = (\Delta f / \Delta V_C) = (-0.32 / R_C C) \quad (\text{Hz} / \text{V})$
Output Frequency of VCO	$f_O = f_n \pm \Delta f$ Where: f_O = VCO output frequency (Hertz) f_n = VCO natural frequency (Hertz) $\Delta f = f_i - f_n$ (Hertz) f_i = external input frequency (Hertz)
Transfer Function of VCO	$K_o = \Delta f / \Delta V$ Where: K_o = input-versus-output transfer function (Hertz per Volt) ΔV = change in the input control voltage (Volts) Δf = change in the output frequency (Hertz)
Phase Difference or Phase Error in Phase Comparator	$\theta_e = \theta_i - \theta_o$ Where: θ_e = phase error (radians) θ_i = phase of the VCO output signal voltage (radians) θ_o = phase of the external input signal voltage (radians)
Transfer Function for a Square-wave Phase Comparator for	$K_d = V_d / \theta_e = 2V_d / \pi$

Phase Errors between 0° to 180°	<p>Where:</p> <p>K_d = transfer function or gain (Volts per Radian)</p> <p>V_d = phase comparator output voltage (Volts)</p> <p>θ_e = phase error ($\theta_i - \theta_o$) (radians)</p> <p>$\pi = 3.14$ radians</p>
PLL Open-loop Gain	<p>$K_L = K_d K_f K_a K_o$</p> <p>Where:</p> <p>K_L = PLL open-loop gain (Hertz per radian)</p> <p>K_d = phase comparator gain (volts per radian)</p> <p>K_f = low-pass filter gain</p> <p>K_a = amplifier gain</p> <p>K_o = VCO gain (Hertz per volt)</p>
Maximum Phase Comparator Output Voltage	<p>$\pm V_d(\max) = [\theta_{e(\max)}](K_d)$</p> <p>$= \pm (\pi / 2) \text{rad} \times (K_d)$</p> <p>Where:</p> <p>$\pm V_d(\max)$ = maximum peak change at the phase comparator output voltage</p> <p>K_d = phase comparator transfer function</p>
Maximum Change in VCO Output Frequency	<p>$\pm \Delta f_{\max} = \pm (\pi / 2) \text{rad} \times K_d K_f K_a K_o$</p>
Capture Range	<p>$\text{capture range} = (2\sqrt{\Delta f_{\max}}) / RC$</p>
Lock Range	<p>$\text{lock range} = 2\Delta f_{\max} = 2\pi K_L$</p> <p>Where:</p> <p>$K_L = K_d K_f K_o$ for a simple loop with a PLF, phase comparator, and VCO</p> <p>$= K_d K_f K_a K_o$ for a loop with an amplifier</p>
VCO Running Frequency	<p>$f_n = f (1 + (0.6 / R_x))$</p> <p>$= (200 / C_o)(1 + (0.6 / R_x))$</p>

	<p>Where:</p> <p>f_n = VCO free-running frequency (Hertz)</p> <p>f = VCO output frequency with pin 10 open circuited (Hertz)</p> <p>R_x = external resistance (kiloohms)</p> <p>C_o = external timing capacitor (microfarads)</p>
VCO Transfer Function	<p>$K_o = (700 / C_o R_o) \text{ (rad/s) / V}$</p> <p>Where:</p> <p>$K_o$ = VCO conversion gain (radians per second per volt)</p> <p>C_o = capacitance (microfarads)</p> <p>R_o = resistance (kiloohms)</p>
Voltage Gain of Operational Amplifier	<p>$A_v = -R_f / (R_s + R_p)$</p> <p>Where:</p> <p>A_v = voltage gain</p> <p>R_f = feedback resistor (ohms)</p> <p>R_s = external resistor connected to pin 1 (ohms)</p> <p>R_p = internal 6 kΩ impedance at pin 1 (ohms)</p>
Open-loop Gain for the Frequency Synthesizer	<p>$K_v = (K_d K_a K_o) / n$</p> <p>Where:</p> <p>n = factor of open-loop gain reduced by frequency divider</p>

CHAPTER 4: AMPLITUDE MODULATION TRANSMISSION

TERMS	DEFINITIONS
Modulation	The process of impressing low-frequency information signals onto a high-frequency carrier signal.
Demodulation	The reverse process of modulation where the received signals are transformed back to their original form.

Amplitude Modulation	The process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.
Radio Frequencies	Frequencies that is high enough to be efficiently radiated by the antenna and propagated through free space.
AM Envelope	The modulated output waveform from an AM modulator is?
AM DSBFC	Sometimes called conventional AM or simply AM.
Lower Sideband	The band of frequencies between $f_c - f_{m(max)}$ and f_c
Lower Side Frequency	Any frequency within the lower sideband is called.
Upper Sideband	The band of frequencies between f_c and $f_c + f_{m(max)}$
Upper Side Frequency	Any frequency within the upper sideband is called?
Coefficient of Modulation	The term used to describe the amount of amplitude change (modulation) present in an AM waveform signal.
Percent Modulation	The coefficient of modulation stated as a percentage.
100%	The maximum percent modulation that can be imposed without causing excessive distortion.
Location	The _____ in a transmitter where modulation occurs determines whether the circuit is a low or a high-level transmitter
Low-Level Modulation	The modulation takes place prior to the output element of the final

	stage of the transmitter.
High-Level Modulation	The modulation takes place in the final element of the final stage where the carrier signal is at its maximum amplitude.
Emitter Modulation	The amplitude of the output signal depends on the amplitude of the input carrier and the voltage gain of the amplifier.
Collector Modulator	A class C modulator capable of nonlinear mixing and the modulating signal is applied directly to the collector.
Up-converter	Used to translate the low-frequency intelligence signals to radio-frequency signals that can be efficiently radiated from an antenna and propagated through free space.
Trapezoidal Pattern	Are used for observing the modulation characteristics of AM transmitters.
Carrier Shift	A form of amplitude distortion introduced when the positive and negative alternations in the AM modulated signal are not equal (nonsymmetrical modulation).
Nonsinusoidal Signals	Complex waveforms comprised of two or more frequencies.
Complex Repetitive Waveforms	Are complex waves made up of two or more harmonically related sine waves and include square, rectangular, and triangular waves.
Quadrature Amplitude Modulation (QAM)	A form of AM where signals from two separate information sources modulate the same carrier frequency at the same time without interfering with each other. The information sources modulate the same carrier after it has been separated into two carrier signals that are 90° out of phase with each other.

CHAPTER 5: AMPLITUDE MODULATION RECEPTION

TERMS	DEFINITIONS
AM Demodulation	The reverse process of AM modulation.
RF Section	The first stage of the receiver of which primary functions are detecting, band limiting, and amplifying the received.
Mixer / Converter	This section down-converts the received RF frequencies to intermediate frequencies (IFs).
IF Section	This section primary functions are amplification and selectivity.
AM Detector	This section demodulates the AM wave and converts it to the original information signal.
Audio Section	This section amplifies the recovered information. Comprises several cascaded audio amplifiers and one or more speakers.
Selectivity	A receiver parameter that is used to measure the ability of the receiver to accept a given band of frequencies and reject all others.
Shape Factor	The ratio of the bandwidth 60dB below maximum signal level and bandwidth 3dB below maximum signal level.
Thermal Noise	The most prevalent form of noise and is directly proportional to bandwidth.
Bandwidth Improvement	Noise reduction ratio achieved by reducing the Bandwidth.
Noise Figure Improvement	The corresponding reduction in the noise figure due to the reduction in bandwidth expressed mathematically in dB.
Sensitivity	The _____ of a receiver is the minimum RF signal level that can be detected at the input to the receiver and still produce a usable demodulated information signal. Also known as receiver threshold.
Dynamic Range	Defined as the difference in decibels between the minimum input level necessary to discern a signal and the input level that will overdrive the receiver and produce distortion.
1-dB Compression Point	Defined as the output power when the RF amplifier response is 1 dB less than the ideal linear-gain response.

Fidelity	A measure of the ability of a communication system to produce, at the output of the receiver, an exact replica of the original source information.
Distortion	Any frequency, phase, or amplitude variations that are present in the demodulated waveform that were not in the original information signal.
Absolute Phase Shift	The total phase shift encountered by a signal and can generally be tolerated as long as all frequencies undergo the same amount of phase delay.
Differential Phase Shift	Occurs when different frequencies undergo different phase shifts and may have a detrimental effect on a complex waveform.
Insertion Loss (IL)	Defined as the ratio of the power transferred to a load with a filter in the circuit to the power transferred to a load without the filter.
Equivalent Noise Temperature	A hypothetical value that cannot be directly measured. A parameter that is used in low-noise, sophisticated radio receivers rather than noise figure.
Coherent / Synchronous Receiver	The frequencies generated in the receiver and used for demodulation are synchronized to oscillator frequencies generated in the transmitter.
Noncoherent / Asynchronous Receiver	Either no frequencies are generated in the receiver or the frequencies used for demodulation are completely independent from the transmitter's carrier frequency.
Tuned Radio Frequency	One of the earliest types of AM receivers and are probably the simplest designed radio receivers available today.
Skin Effect	A phenomenon at radio frequencies where current flow is limited to the outermost area of a conductor.
Stagger Tuning	A technique where TRF receiver's instability can be reduced somewhat by tuning each amplifier to a slightly different frequency, slightly above or below the desired center frequency.
Heterodyne	Means to mix two frequencies together in a nonlinear device or to translate one frequency to another using nonlinear mixing.
Preselector	A broad-tuned bandpass filter with an adjustable center frequency that is tuned to desired carrier frequency.

455 kHz	The most common intermediate frequency used in AM broadcast-band receivers is _____.
IF Section	Consists of a series of IF amplifiers and bandpass filters and is often called IF strip.
Intermediate Frequency	Refer to frequencies that are used within a transmitter or receiver that fall somewhere between the radio frequencies and the original source information frequencies.
Gang Tuning	Means that the two adjustments are mechanically tied together so that a single adjustment will change the center frequency of the preselector and, at the same time, change the local oscillator frequency.
High-side Injection / High-beat Injection	When the local oscillator is tuned above the RF it is?
Low-side Injection / Low-beat Injection	When the local oscillator is tuned below the RF it is?
Sideband Inversion	The side frequencies undergo a sideband reversal during the heterodyning process called?
Tracking	The ability of the local oscillator in a receiver to oscillate above or below the selected radio frequency carrier by an amount equal to the intermediate frequency throughout the entire radio frequency band.
Tracking Error	The difference between the actual oscillator frequency and the desired frequency.
Image Frequency	Any frequency other than the selected radio frequency carrier that, if allowed to enter a receiver and mix with the local oscillator, will produce a cross-product frequency that is equal to the intermediate frequency.
Image-frequency Rejection Ratio	A numerical measure of the ability of a preselector to reject the image frequency.
Double Spotting	Occurs when a receiver picks up the same station at two nearby points on the receiver tuning dial.
RF Amplifier	A high-gain, low-noise, tuned amplifier that, when used, is the first active stage encountered by the received signal.

Low-noise Amplifier (LNA)	High-performance microwave receivers require a _____ as the input stage of the RF section to optimize their noise figure.
Mesa Semiconductor FET Semiconductor FET (MESFET)	A FET with a metal-semiconductor junction at the gate of the device, called a Schottky barrier.
NE / SA5200	A wideband, unconditionally stable, low-power, dual-gain linear integrated-circuit RF amplifier manufactured by Signetics Corporation.
Mixer / Converter Stage	This section purpose is to down-convert the incoming radio frequencies to intermediate frequencies proportional to bandwidth.
Conversion Gain	The difference between the level of the IF output with an RF input signal to the level of the IF output with an IF input signal.
Self-excited Mixer	A configuration where the mixer excites itself by feeding energy back to the local oscillator tank circuit to sustain oscillations noise figure.
NE / SA602A	A low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator.
Intermediate Frequency (IF) Amplifier	Are relatively high-gain amplifiers that are very similar to RF amplifiers, except that IF amplifiers operate over a relatively narrow, fixed frequency band.
Inductive or Transformer Coupling	The most common technique used for coupling where the voltage that is applied to the primary windings of a transformer is transferred to the secondary windings.
Inductance	Ability of a coil to induce a voltage within its windings.
Mutual Inductance	Ability of one coil to induce a voltage in another coil.
Coefficient of Coupling	The ratio of the secondary flux to the primary flux.
Flux Linkage	The transfer of flux from the primary to the secondary windings and is directly proportional to the coefficient of coupling.
	The point where the reflected resistance is equal to the primary

Critical Coupling	resistance and the Q of the primary tank circuit is halved and the bandwidth doubled.
Double Peaking	Is caused by the reactive element of the reflected impedance being significant enough to change the resonant frequency of the primary tuned circuit.
Optimum Coupling	The coefficient of coupling approximately 50% greater than the critical value yields a good compromise between flat response and steep skirts.
IF Cans	IF transformers come as specially designed tuned circuits in groundable metal packages called _____.
CA3028A	A differential cascoded amplifier designed for use in communications and industrial equipment as an IF or RF amplifier at frequencies from dc to 120 MHz.
AM Detector	The function of this circuit is to demodulate the AM signal and recover or reproduce the original source information.
Peak Detector	A simple noncoherent AM demodulator using a diode. Also called as diode, shape, or envelope detector.
Rectifier Distortion	A distortion in the detection process where the RC time constant is too short, the output waveform resembles a half-wave rectified signal.
Diagonal Clipping	A distortion in the detection process where the RC time constant is too long, the slope of the output waveform cannot follow the trailing slope of the envelope.
Automatic Gain Control (AGC)	A circuit that compensates for minor variations in the received RF signal.
Delayed AGC	It prevents the AGC feedback voltage from reaching the RF or IF amplifiers until the RF level exceeds a predetermined magnitude.
Forward AGC	Is similar to conventional AGC except that the receive signal is monitored closer to the front end of the receiver and the correction voltage is fed forward to the IF amplifiers.
Squelch Circuit	Its purpose is to quiet a receiver in the absence of a received signal.

Limiters / Clippers	Are used to remove sporadic, high-amplitude noise transients of short duration, such as impulse noise in the audio section of a receiver.
Signal-to-Notched Noise Ratio	A method of measuring signal strength relative to noise strength where an RF carrier modulated 30% by a 1-kHz tone is applied to the input of the receiver.
LM1820	A National Semiconductor Corporation linear integrated circuit AM radio chip that has an onboard RF amplifier, mixer, local oscillator, and IF amplifier stages. An LIC audio amplifier, such as the LM386, and a speaker are necessary to complete a functional receiver.
PLL Receivers	This receiver would need only two external components: a volume control and a station tuning control.
Net Receiver Gain	The ratio of the demodulated signal level at the output of the receiver (audio) to the RF signal level at the input to the receiver, or the difference between the audio signal level in dBm and the RF signal level in dBm.
System Gain	Includes all the gains and losses incurred by a signal as it propagates from the transmitter output stage to the output of the detector in the receiver and includes antenna gain and transmission line and propagation losses.

CHAPTER 6: SINGLE – SIDEBAND COMMUNICATIONS SYSTEMS

TERM	DESCRIPTION
AM Single-sideband Full Carrier (SSBFC)	A form of amplitude modulation in which the carrier is transmitted at full power but only one of the sidebands is transmitted.
AM Single-sideband Suppressed Carrier (SSBSC)	A form of amplitude modulation in which the carrier is totally suppressed and one of the sidebands removed.
AM Single-sideband Reduced Carrier (SSBRC)	A form of amplitude modulation in which one sideband is totally removed and the carrier voltage is reduced to approximately 10% of its unmodulated amplitude. Sometimes called single-sideband reinserted carrier.
Pilot Carrier	It is the reinserted carrier in SSBRC for demodulation purposes.

AM Independent Sideband (ISB)	A form of amplitude modulation in which a single carrier frequency is independently modulated by two different modulating signals.
VSB System	_____ is the picture portion of a commercial television broadcasting signal.
Bandwidth Conservation and Power Efficiency	Are obvious advantages of single-sideband suppressed- and reduced-carrier transmission over conventional double- sideband full-carrier transmission.
Signal-to-Noise Ratio	Are obvious advantages of single-sideband suppressed- and reduced-carrier transmission over conventional double- sideband full-carrier transmission.
Selective Fading	With double-sideband transmission, the two sidebands and carrier may propagate through the transmission media by different paths and therefore, experience different transmission impairments. This condition is called?
Sideband Fading	A condition in double-sideband transmission where one sideband is significantly attenuated.
Carrier-Amplitude Fading	A form of selective fading where there is a reduction of the carrier level of a 100%-modulated wave that will make the carrier voltage less than the vector sum of the two sidebands.
Carrier or Sideband Phase Shift	A condition where the relative positions of the carrier and sideband vectors of the received signal change, causing a decided change in the shape of the envelope, causing a severely distorted demodulated signal.
AM Modulator	A product modulator where the output signal is the product of the modulating signal and the carrier
DSBSC Modulators	Modulator circuits that inherently remove the carrier during the modulation process.
Balanced Modulator	A circuit that produces a double-sideband suppressed-carrier signal.
Balanced Ring Modulator	A balanced modulator that is constructed with diodes and transformers. Sometimes called balanced lattice modulator.
Carrier Leak	The small carrier component that is always present in the output signal of a balanced modulator.
Balanced Bridge Modulator	The operation of this balanced modulator as the balanced ring modulator is completely dependent on the switching action of diodes D1 through D4 under the influence of the carrier and modulating signal voltages.

LM1497 / 1596 Balanced Modulator IC	A double-balanced modulator/demodulator that produces an output signal that is proportional to the product of its input signals.
Linear Summer	The circuit where the carrier is reinserted.
Filter, Phase-Shift, and Third Method	Three methods for single-sideband generation.
Crystal Lattice, Ceramic, Mechanical, Saw Filters	Types of single-sideband filters.
Mechanical Filter	A mechanically resonant transducer that receives electrical energy, converts it to mechanical vibrations, and then converts the vibrations back to electrical energy at its output.
Surface Acoustic Wave Filters	Filters that use acoustic energy rather than electro-mechanical energy to provide excellent performance for precise bandpass filtering.
Destructive Interference	Reflected energy that cancels and attenuates the incident wave energy.
Constructive Interference	Reflected energy that aids the incident wave energy.
Unidirectional Transducer	A transducer which launches the acoustic wave in only one direction.
frequency offset error	Any difference between the transmit and receive local oscillator frequencies produces a _____ in the demodulated information signal.
tonal variation	Fifty hertz or more offset is distinguishable by a normal listener as a _____.
Carrier Recovery Circuit	A narrowband PLL that tracks the pilot carrier in the composite SSBRC receiver signal and uses the recovered carrier to generate coherent local oscillator frequencies in the synthesizer.
Multichannel Pilto Carrier	An SSB receiver that uses a PLL carrier recovery circuit and a frequency synthesizer to produce coherent local and beat frequency oscillator frequencies.
Amplitude- Companding Single-Sideband (ACSSB)	Systems that provide narrowband voice communications for land-mobile services with nearly the quality achieved with FM systems and do it using less than one-third the bandwidth.
Multiplexing	The process of combining transmissions from more than one source and transmitting them over a common facility, such as metallic or optical fiber cable or a radio-frequency channel.

Single-Sideband Suppressed-Carrier Transmission	A transmission that can be used to combine hundreds or even thousands of narrowband channels into single, composite wideband channel without the channels interfering with each other.
Peak Envelope Power (PEP) & Peak Envelope Voltage (PEV)	Single-sideband transmitters are rated in _____ and _____.

CHAPTER 7: ANGLE MODULATION TRANSMISSION

TERMS	DEFINITION
FM and PM	Two forms of angle modulation.
Angle modulation	It was first introduced in the year 1931 as an alternative to amplitude modulation.
Major E. H. Armstrong	He developed the first successful FM radio system in 1936, and in July 1939, the first regularly scheduled broad-casting of FM signals began in Alpine, New Jersey. Also developed the superheterodyne receiver.
Angle Modulation	A modulation that results whenever the phase angle (θ) of a sinusoidal wave is varied with respect to time.
<p>Angle Modulated wave is expressed mathematically as:</p> $m(t) = V_c \cos [\omega_c t + \phi(t)]$ <p> $m(t)$ = angle modulated wave V_c = Peak carrier amplitude (volts) ω_c = carrier radian frequency (angular velocity) $\phi(t)$ = instantaneous phase deviation (radian) </p>	
Direct Frequency Modulation (FM)	Varying the frequency of a constant-amplitude carrier directly proportional to the amplitude of the modulating signal at a rate equal to the frequency of the modulating signal.
Direct Phase Modulation (PM)	Varying the phase of a constant-amplitude carrier directly proportional to the amplitude of the modulating signal at a rate equal to the frequency of the modulating signal.

Phase Deviation ($\Delta\theta$)	The relative angular displacement (shift) of the carrier phase in radians in respect to the reference phase.
Frequency Deviation (ΔF)	The relative displacement of the carrier frequency in hertz in respect to its unmodulated value.
Carrier Rests Frequency	The original unmodulated carrier frequency in the resultant angle-modulated waveform.
Instantaneous Phase Deviation = ($\phi(t)$ rad)	The instantaneous change in the phase of the carrier at a given instant of time and indicates how much the phase of the carrier is changing with respect to its reference phase.
Instantaneous Phase $=\omega_c t + \phi(t)$ rad	The precise phase of the carrier at a given instant of time.
Instantaneous Frequency Deviation $=\phi'(t)$ rad/sec	The instantaneous change in frequency of the carrier and is defined as the first time derivative of the instantaneous phase deviation.
Instantaneous Frequency $=\omega_c + \phi'(t)$ rad/sec	The precise frequency of the carrier at a given instant of time and is defined as the first time derivative of the instantaneous phase.
Phase Modulation	It is define as angle modulation in which the instantaneous deviation is proportional to the amplitude of the modulating signal voltage and the instantaneous frequency deviation is proportional to the slope or first derivative of the modulating signal.
<p>For a modulating signal $V_m(t)$, the phase and frequency modulation are</p> <p style="text-align: center;">Phase modulation = $\phi(t) = K V_m(t)$ rad</p> <p style="text-align: center;">Frequency modulation = $+\phi'(t) = K_1 V_m(t)$ rad/sec</p>	
Deviation Sensitivities	Are the output-versus-input transfer functions for the modulators, which give the relationship between what output parameter changes in respect to specified changes in the input signal.
Peak Phase Deviation	It is the radian for the phase modulated carrier.
Index of Modulation	Peak Phase Deviation is sometimes called?
Frequency Deviation	The change in frequency that occurs in the carrier when it is acted on by a modulating-signal frequency.
Carrier Swing	The peak-to-peak frequency deviation ($2\Delta f$) is sometimes called?

Percent Modulation	The ratio of the frequency deviation actually produced to the maximum frequency deviation allowed by law stated in percent form.
<p style="text-align: center;">Percent modulation is</p> $\% \text{ modulation} = \frac{\Delta f_{(\text{actual})}}{\Delta f_{(\text{max})}} \times 100$	
Phase Modulator	A circuit in which the carrier is varied in such a way that its instantaneous phase is proportional to the modulating signal.
Rest Frequency	The unmodulated carrier is a single frequency sinusoidal and is commonly called?
Frequency Modulator	A circuit which the carrier is varied in such a way that its instantaneous phase is proportional to the integral of the modulating signal.
Frequency deviator	Frequency modulator is often called?
<p style="text-align: center;">Four commonly used equivalences are as follows:</p> <ul style="list-style-type: none"> ➤ PM modulator = differentiator followed by an FM modulator ➤ PM demodulator = FM demodulator followed by an integrator ➤ FM modulator = integrator followed by a PM modulator ➤ FM demodulator = PM demodulator followed by a differentiator 	
Bessel Function	It is the first kind for several values of modulation index provides the number of side frequency pairs and their corresponding magnitude.
First Carrier Null	The carrier component goes to zero is called?
Second Carrier Null	The carrier component once again disappears is called?
1%	A side frequency is not considered significant unless it has an amplitude equal to or greater than ____ of the unmodulated carrier amplitude.
Low-index Case	The modulation index is less than 1.
Medium Index	Modulation indices greater than 1 and less than 10.
High-index Case	The modulation index is greater than 10.
Narrowband FM	Low-index FM systems are sometimes called?
Carson's Rule $B = 2(\Delta f + f_m) \text{ Hz}$	A rule which is an approximation and gives transmission bandwidths that are slightly narrower than the bandwidths. It defines a bandwidth

f_m = modulating signal Δf = peak frequency deviation	that includes approximately 98% of the total power in the modulated wave.
Deviation Ratio (DR)	The worst-case modulation index and is equal to the maximum peak frequency deviation divided by the maximum modulating-signal frequency.
<p style="text-align: center;">Deviation Ratio</p> $DR = \frac{\Delta f_{(max)}}{f_{m(max)}}$ <p style="text-align: center;">DR = Deviation Ratio (unit less) $\Delta f_{(max)}$ = maximum peak frequency deviation (hertz) $f_{m(max)}$ = maximum modulating signal frequency (hertz)</p>	
20 MHz	The FCC has assigned the commercial FM broadcast service a _____ band of frequencies that extends from 88 MHz to 108 MHz.
200 kHz	The 20-MHz band is divided into 100, _____ wide channels beginning at 88.1 MHz.
75 kHz ; 15 kHz	To provide high-quality, reliable music, the maximum frequency deviation allowed is _____ with a maximum modulating-signal frequency of _____.
Adjacent Channel Interference	The highest side frequencies from one channel are allowed to spill over into adjacent channels, producing an interference known as?
200 kHz	It is the wide of the guard band is usually on either side of each assigned channel.
<p style="text-align: center;">The average power in the unmodulated carrier is</p> $p_c = \frac{v_c^2}{2R} w$ <p style="text-align: center;">p_c = carrier power (watts) v_c = peak unmodulated carrier voltage (volts) R = load resistance (ohms)</p>	
FM Noise Triangle	The noise voltage at the output of an FM demodulator increases linearly with frequency. This is called?
Pre-emphasis	The high-frequency modulating signals are emphasized or boosted in amplitude in the transmitter prior to performing modulation.
De-emphasis	The reciprocal of pre-emphasis that restores the original amplitude-versus-frequency characteristics to the information signals.
Pre-emphasis Network	A circuit that provides a constant increase in the amplitude of the modulating signal with an increase in frequency.
Break Frequency	It occurs at the frequency where x_c and x_L equal R.

$f_b = \frac{1}{2\pi RC}$	
Direct FM	It is a angle modulation in which the frequency of the carrier is varied directly by the modulating signal.
Direct FM (Indirect PM)	When the frequency of the carrier is modulated by the information signal, _____ results.
Direct PM (Indirect FM)	When the phase of the carrier is modulated by the information signal, _____ results.
Varactor Diode, FM Reactance, Linear IC Modulations	Three common methods for producing direct frequency modulation.
Varactor Diode	It is used to transform changes in the modulating signal amplitude to changes in the frequency.
Varactor Diode Direct FM Modulator	Direct frequency modulator used for low-index Applications, such as two-way mobile radio.
FM Reactance Modulator	A direct FM modulator using a JFET as the active device.
Linear IC VCO and Function Generators	Can generate a direct FM output waveform that is relatively stable, accurate, and directly proportional to the input modulating signal.
Direct PM	Angle modulation in which the frequency of the carrier is deviated indirectly by the modulating signal.
Varactor Diode and Transistor Direct PM Modulator	Two common methods for producing direct phase modulation.
Frequency Up- Conversion	The process of up-converting the frequency of the modulated carrier after modulation has been performed.
Heterodyning and Frequency Multiplication	Two basic methods of performing frequency up-conversion.
Heterodyne Method	An up-conversion method where a low-frequency modulated carrier can either be up- or down- converted to a different location in the frequency spectrum without changing its modulation properties.
Multiplication Method	An up-conversion method where the modulation properties of a carrier can be increased at the same time that the carrier frequency is up-converted.

Direct FM Transmitters	Transmitters that produce an output waveform in which the frequency deviation is directly proportional to the modulating signal.
Automatic Frequency Control (AFC)	A circuit that compares the frequency of the non crystal carrier oscillator to a crystal reference oscillator and then produces a correction voltage proportional to the difference between the frequencies.
Frequency Discriminator	A frequency-selective device whose output voltage is proportional to the difference between the input frequency and its resonant frequency.
Wipe Off	When you remove the modulation from the FM wave is called?
dc Correction Voltage	A voltage added to the modulating signal to automatically adjust the master oscillator's center frequency to compensate for the low-frequency drift.
Wideband FM Transmitter	A transmitter that uses a phase-locked loop to achieve crystal stability from a VCO master oscillator and at the same time, generate a high index, wideband FM output signal.
FM Modulator	It is preceded by a differentiator generates a PM waveform.
Indirect FM Transmitters	Transmitters that produce an output waveform in which phase deviation is directly proportional to the modulating signal.
PM Modulator	It is preceded by an integrator produces an FM waveform.
Noise Immunity	Probably the most significant advantage of angle modulation over amplitude modulation transmission.
Capture Effect	It allows a receiver to differentiate between two signals received with the same frequency.

CHAPTER 8: ANGLE MODULATION RECEPTION AND FM STEREO

TERMS	DEFINITIONS
FM Receivers	In this receiver, the voltage at the output of the audio detector is directly proportional to the frequency deviation at its input.

PM Receivers	In this receiver, the voltage at the output of the audio detector is directly proportional to the phase deviation at its input.
Angle Modulation	A modulation where the information is impressed onto the carrier in the form of frequency or phase variations.
Limiting	A method used to remove amplitude variations caused by noise from the composite waveform simply by clipping the peaks of the envelope prior to detection.
Pre-selector	The section that rejects the image frequency in FM receivers.
RF Amplifier	The section that establishes the signal-to-noise ratio and noise figure in FM receivers.
Mixer / Converter	The section that down-converts RF to IF.
IF Amplifiers	The section that provide most of the gain and selectivity.
Detector	The section that removes the information from the modulated wave.
Limiter, Frequency Discriminator and De-emphasis Network	The envelope (peak) detector common to AM receivers is replaced in FM receivers by a _____, _____, and _____.
Frequency Discriminator	The circuit that extracts the information from the modulated wave.
FM Demodulators	Are frequency-dependent circuits designed to produce an output voltage that is proportional to the instantaneous frequency at its input.
Slope Detector, Foster-Seely Discriminator,	Circuits used for demodulating FM signals.

Ratio Detector, PLL Demodulator, and Quadrature Detector	
Tuned-Circuit Frequency Discriminators	Circuits that convert FM to AM and then demodulate the AM envelope with conventional peak detectors.
Slope Detector	A tuned-circuit frequency discriminator that has the most nonlinear voltage-versus-frequency characteristics and, therefore, is seldom used.
Balanced Slope Detector	Is simply two single-ended slope detectors connected in parallel and fed 180° out of phase.
Foster-Seeley Discriminator	Sometimes called a phase shift discriminator that is a tuned-circuit frequency discriminator whose operation is very similar to that of a balanced slope detector.
S-curve	The typical voltage-versus-frequency response curve for a Foster-Seeley discriminator.
Ratio Detector	An FM demodulator that is relatively immune to amplitude variations in its input signal.
PLL FM Demodulator	This FM demodulator requires no tuned circuits and automatically compensates for changes in the carrier frequency due to instability in the transmit oscillator.
Quadrature FM Demodulator	Sometimes called a coincidence detector that extracts the original information signal from the composite IF waveform by multiplying two quadrature (90° out of phase) signals.
Limiters	A special circuit that removes the unwanted amplitude variations since with FM, the information is contained in frequency variations.
Threshold, Quieting, or Capture Level	The limiter circuit produces a constant-amplitude output for all input signals above a prescribed minimum input level, which is often

	called the _____.
FM Thresholding, FM Quieting, or FM Capture Effect	The improvement in the S/N ratio when the peaks of the signal have the limiter so far into saturation that the weaker noise is totally eliminated.
Capture Effect	The inherent ability of FM to diminish the effects of interfering signals. Also, the ability to differentiate between two signals received at the same frequency.
Capture Ratio of an FM Receiver	Is the minimum dB difference in signal strength between two received signals necessary for the capture effect to suppress the weaker signal.
NE/SA614A	An improved monolithic low-power FM IF system manufactured by Signetics Corporation. It is a high gain, high frequency device that offers low-power consumption and excellent input sensitivity at 455 kHz.
Quadrature Detector	A multiplier cell similar to a mixer stage, but instead of mixing two different frequencies, it mixes two signals with the same frequencies but with different phases.
NE/SA616	A low-voltage, high-performance monolithic FM IF system similar to the NE/SA614A except with the addition of a mixer/oscillator circuit.
TDA7000	A monolithic integrated-circuit FM radio system manufactured by Signetics Corporation for monolithic FM portable radios. A complete FM radio receiver on a single integrated-circuit chip.
Frequency-Locked-Loop	A circuit that is used to reduce the total harmonic distortion (THD) by compressing the IF frequency swing (deviation).
Stereophonic Transmission	With this transmission, the information signal is spatially divided into two 50-Hz to 15-kHz audio channels (a left and a right).
Subsidiary	

Communications Authorization (SCA)	Used to broadcast uninterrupted music to private subscribers, such as department stores, restaurants, and medical offices equipped with special receivers; Sometimes cordially refer to as “elevator music”
Frequency Division Multiplexing (FDM)	The process of placing two or more independent channels next to each other in the frequency domain (stacking the channels), and then modulating a single high-frequency carrier with the combined signal.
60 kHz To 74 kHz	The primary audio channel remained at 50 Hz to 15 kHz, while an additional SCA channel is frequency translated to the _____ passband.
7 kHz	The SCA subcarrier may be AM single- or double- sideband transmission or FM with a maximum modulating-signal frequency of _____.
19 kHz	The frequency of the pilot carrier of FM stereo transmission.
Direct PM (Indirect FM)	When the phase of the carrier is modulated by the information signal, _____ results.
XR-1310	A monolithic FM stereo demodulator that uses PLL techniques to derive the right and left audio channels from the composite stereo signal.
Two-Way Mobile Radio	Half-duplex, one-to-many radio communications with no dial tone.
Class D Citizens Band (CB) Radio	Provides 26.96 to 27.41 MHz public, non-commercial radio service for either personal or business use utilizing push-to-talk AM DSBFC and AM SSBFC.
Amateur (HAM) Radio	Cover a broad-frequency band from 1.8 MHz to above 300 MHz. Designed for personal use without pecuniary interest.
Aeronautical Broadcasting Service	Provides 2.8 MHz to 457 MHz. ABS disseminates information for the purposes of air navigation and air-to-ground communications

(ABS)	utilizing conventional AM and various forms of AM SSB in the HF, MF, and VHF frequency bands.
Mobile Telephone Service	Full-duplex, on-to-one radio telephone communications.
Personal Communications Satellite Service (PCSS)	Provides worldwide telecommunication service using handheld telephones that communicate with each other through low earth-orbit satellite repeaters incorporating QPSK modulation and both FDMA and TDMA.
Two-Way FM Radio Communications	Is used extensively for public safety mobile communications, such as police and fire departments and emergency medical services.
5 kHz ; 3 kHz	The maximum frequency deviation for two-way FM transmitters is typically _____, and the maximum modulating-signal frequency is _____.
Push-To-Talk (PTT)	Transmissions are initiated by closing a _____ switch, which turns on the transmitter and shuts off the receiver.
Mobile Radio	It was used as early as 1921 when the Detroit Police Department used a mobile radio system that operated at a frequency close to 2 MHz.
Electronic Push-To-Talk	It was used rather than a simple mechanical switch to reduce the static noise associated with contact bounce in mechanical switches.
Voice-Operated Transmitter (VOX)	Transmitters equipped with _____ are automatically keyed each time the operator speaks into the microphone, regardless of whether the PTT button is depressed.

CHAPTER 9: DIGITAL MODULATION

TERMS	DEFINITIONS
Electronic Communication	Is the transmission, reception, and processing of information with the use of electronic circuits.
Information	Is defined as knowledge or intelligence that is communicated between two or more points.
Digital Modulation	Is the transmittal of digitally modulated analog signals (carriers) between two or more points in a communication system.
Digital Transmission	System involving the transmission of digital pulses.
Amplitude Shift Keying (ASK)	The information signal is digital and the amplitude (V) of the carrier is varied proportional to the information signal.
Frequency Shift Keying (FSK)	The information signal is digital and the frequency (f) of the carrier is varied proportional to the information signal.
Phase Shift Keying (PSK)	The information signal is digital and the phase (θ) of the carrier is varied proportional to the information signal.
Quadrature Amplitude Modulation (QAM)	A modulation where both the amplitude and the phase are varied proportional to the information signal.
Pre-coder	Performs level conversion and then codes the incoming data into groups of bits that modulate an analog carrier.
Information Theory	Is a highly theoretical study of the efficient use of bandwidth to propagate information through electronic communications systems.
Information Capacity	Is a measure of how much information can be propagated through a communications system and is a function of bandwidth and transmission time.
Binary Digit / Bit	The most basic digital symbol used to represent information.
R. Hartley	In 1928, _____ of Bell Telephone Laboratories developed a useful relationship among bandwidth, transmission time, and information capacity.

Claude E. Shannon	In 1948, mathematician _____ (also of Bell Telephone Laboratories) published a paper in the Bell System Technical Journal relating the information capacity of a communications channel to bandwidth and signal-to-noise ratio.
M	Simply represents a digit that corresponds to the number of conditions, levels, or combinations possible for a given number of binary variables.
Bit Rate	Refers to the rate of change of a digital information signal, which is usually binary.
Baud	Refers to the rate of change of a signal on a transmission medium after encoding and modulation have occurred.
Signaling Element	Sometimes called a symbol and could be encoded as a change in the amplitude, frequency, or phase.
Nyquist Bandwidth	The minimum theoretical bandwidth necessary to propagate a signal.
H. Nyquist	According to _____, binary digital signals can be propagated through an ideal noiseless transmission medium at a rate equal to two times the bandwidth of the medium.
On-Off Keying	The carrier is either "on" or "off" which is why amplitude-shift keying is sometimes referred to as _____.
Mark	A logic 1 frequency (f_m) for FSK.
Space	A logic 0 frequency (f_s) for FSK.
Peak Frequency Deviation (Δf)	The mark and space frequencies are separated from the carrier frequency by the _____ and from each other by Δf .
Δf	_____ is the peak frequency deviation of the carrier and is equal to the difference between the carrier rest frequency and either the mark or space frequency.
Noncoherent Detection	A type of FSK detection wherein there is no frequency involved in the demodulation process that is synchronized either in phase, frequency, or both with the incoming FSK signal.
	A type of FSK detection wherein the incoming FSK signal is multiplied by a recovered carrier signal that has exact same

Coherent Detection	frequency and phase as the transmitter reference.
Continuous-Phase FSK (CP-FSK)	Is binary FSK except the mark and space frequencies are synchronized with the input binary bit rate.
Constellation Diagram	A signal state-space diagram is similar to a phasor diagram except that the entire phasor is not drawn. Only the relative positions of the peaks of the phasors are shown.
Balanced Modulator	Is a product modulator; the output signal is the product of the two input signals.
Coherent Carrier Recovery Circuit	Detect and regenerates a carrier signal that is both frequency and phase coherent with the original transmit carrier.
Quaternary PSK (QPSK)	Also known as quadrature PSK that is another form of angle-modulated, constant-amplitude digital modulation.
Dibit	A group of two bits.
I Bit	It modulates the carrier that is in phase with the reference oscillator.
Q Bit	It modulates the carrier that is 90 out of phase or in quadrature with reference carrier.
QPSK Modulator	Is two BPSK modulators combined in parallel.
$\frac{1}{4}$	The highest fundamental frequency present at the data input to the I or balanced modulator is equal to _____ of the input data rate.
$\frac{1}{2}$	The fastest output rate of change (baud) is also equal to _____ of the input bit rate.
Bit Combining Circuit	The outputs of the product detectors are fed to the _____, where they are converted from parallel I and Q data channels to a single binary output data stream.
Offset QPSK (OQPSK)	Is a modified form of QPSK where the bit waveforms on the I and Q channels are offset or shifted in phase from each other by one-half of a bit time.
Limited Phase Shift	The advantage of OQPSK is the _____ that must be imparted during modulation.
8 PSK	With _____, three bits are encoded, forming eight different output phases.

Tribit	Group of 3 bits.
Gray Code	Also known as maximum distance code used to reduce the number of transmission errors.
Parallel-to-Serial Logic Circuit	Converts the I/C and Q/C bit pairs to serial, Q, and C output data streams.
Quadbits	Group of 4 bits.
11.25°	16-PSK can undergo only a _____ phase shift during transmission and still retain its integrity. .
8 – QAM	Is an M-ary encoding technique where M=8. The output signal from this modulator is not a constant-amplitude signal
Scrambling	The process of introducing transitions (pulses) into the binary signal using a prescribed algorithm.
Descrambler	It uses the same algorithm for scrambling to remove the transitions.
Differential Phase-Shift Keying (DPSK)	Is an alternative form of digital modulation where the binary input is contained in the difference between two successive signalling elements rather than the absolute phase.
Trellis Code Modulation (TCM)	Data transmission rates in excess of 56 kbps can be achieved, over standard telephone circuits using an encoding technique called _____.
Dr. Ungerboeck	_____ at IBM Zurich Research Laboratory developed TCM, which involves using convolutional (tree codes, which combines encoding and modulation to reduce the probability of error, thus improving the bit error performance.
Trellis Coding	Defines the manner in which signal-state transitions are allowed to occur, and transitions that do not follow this pattern are interpreted in the receiver as transmission errors
Euclidean Distance	The distance between symbols on the constellation of the TCM coding scheme on standard QAM.

Carrier-To-Noise Power Ratio	Is the ratio of the average carrier power (the combined power of the carrier and its associated sidebands) to the thermal noise power.
Energy Per Bit	Is simply the energy of a single bit of information.
Antipodal Signaling	FCC approves FM stereo broadcasting, which spurs the development of FM. Citizens band (CB) radio first used.
Noncoherent (Asynchronous) And Coherent (Synchronous)	U.S. radio stations begin broadcasting stereophonic sound.
Noncoherent FSK	T1 (transmission 1) digital carrier systems introduced.
Coherent FSK	First commercial communications satellite launched.

CHAPTER 10: DIGITAL TRANSMISSION

TERMS	DEFINITIONS
Digital Transmission	Is the transmittal of digital signals between two or more points in a communications system.
AT&T	_____ developed the first digital transmission system for the purpose of carrying digitally encoded analog signals, such as human voice, over metallic wire cables between telephone offices.
Noise Immunity	The primary advantage of digital transmission over analog transmission.
Multiplexing	Digital signals are also better suited than analog signals for processing and combining using a technique called ____.

Digital Signal Processing (DSP)	Is the processing of analog signals using digital methods and includes bandlimiting the signal with filters, amplitude equalization, and phase shifting.
Signal Regeneration	Digital transmission systems are more resistant to analog systems to add noise because they use _____ rather than signal amplification.
Pulse Modulation	Consist essentially of sampling analog information signals and then converting those samples into discrete pulses and transporting the pulses from a source to a destination over a physical transmission medium.
PWM, PPM, PAM And PCM	The four predominant methods of pulse modulation.
Pulse Width Modulation (PWM)	Sometimes called pulse duration modulation (PDM) or pulse length modulation (PLM), as the width (active portion of the duty cycle) of an amplitude pulse is varied proportional to the amplitude of the analog signal at the time the signal is sampled.
Pulse Position Modulation (PPM)	The position of a constant-width pulse within a prescribed time slot is varied according to the amplitude of the sample of the analog signal.
Pulse Amplitude Modulation	The amplitude of a constant-width, constant-position pulse is varied according to the amplitude of the sample of the analog signal.
Pulse Code Modulation (PCM)	The analog signal is sampled and then converted to a serial n-bit binary code for transmission.
Alex H. Reeves	_____ is credited with inventing PCM in 1937 while working for Bell Labs at its Paris laboratories.
Sample-and-Hold Circuit	A circuit that periodically samples the analog input signal and converts those samples to a multilevel PAM signal.

Repeaters	The transmission line _____ are placed at prescribed distances to regenerate the digital pulses.
Codec (Coder / Decoder)	An integrated circuit that performs the PCM encoding and decoding functions.
Sampling Circuit	The function of a _____ in a PCM transmitter is to periodically sample the continually changing analog input voltage and convert those samples to a series of constant-amplitude pulses that can more easily be converted to binary PCM code.
Aperture Error	The sampling process alters the frequency spectrum and introduces an error called _____.
Storage Time	The _____ of the capacitor is called the A/D conversion time because it is during this time that the ADC converts the sample voltage to a PCM code.
Aperture Distortion	If the input to the ADC is changing while it is performing the conversion, _____ results.
Nyquist Sampling	_____ theorem establishes the minimum sampling rate (f_s) that can be used for a given PCM system.
N-Bit Codes	The binary codes used for PCM are _____, where n may be any positive integer greater than 1.
Most Significant Bit (MSB)	The sign bit in a sign-magnitude code.
Quantization	Is the process of converting an infinite number of possibilities to a finite number of conditions. Is the process of rounding off the amplitudes of flat-top samples to a manageable number of levels.
Folded Binary Code	

	A type of code where the codes on the bottom half of the table are a mirror image of the codes on the top half, except for the sign bit.
Quantization Interval or Quantum	The magnitude difference between adjacent steps.
Overload Distortion	If the magnitude of the sample exceeds the highest quantization interval, _____ (also called peak limiting) occurs.
Quantization Error (Q_e) Quantization Noise (Q_n)	Any round-off errors in the transmitted signal are reproduced when the code is converted back to analog in the receiver.
Dynamic Ratio	Is the ratio of the largest possible magnitude to the smallest possible magnitude (other than 0V) that can be decoded by the digital-to-analog converter in the receiver.
Idle Channel Noise	During times when there is no analog input signal, the only input to the PAM sampler is random, thermal noise also called as _____, that is converted to a PAM sample just as if it were a signal.
Midtread Quantization	A way to reduce idle channel noise wherein the first quantization interval is made larger in amplitude than the rest of the steps.
Companding	Is the process of compressing and then expanding.
μ-Law and A-law Companding	Two methods of companding:
Digital Companding	Involves compression in the transmitter after the input sample has been converted to a linear PCM code and then expansion in the receiver prior to PCM decoding.
Vacoders	When digitizing speech signals only, special voice encoders/decoders called _____ are often used

Linear Predictive	A _____ coder extracts the most significant portions of speech information directly from the time waveform rather than from the frequency spectrum as with the channel and formant vocoders.
Delta	_____ modulation uses a single-bit PCM code to achieve digital transmission of analog signals
Slope Overload and Granular Subdivision	Two problems associated with delta modulations that do not occur with conventional PCM.
Differential PCM (DPCM)	With _____, the difference in the amplitude of two successive samples is transmitted rather than the actual sample.
Ring test	The secondary lobes are called _____.
Inter symbol interference (ISI)	_____ causes crosstalk between channels that occupy adjacent time slots in a time-division-multiplexed carrier system.
Equalizers	Special filters called _____ are inserted in the transmission path to “equalize” the distortion for all frequencies, creating uniform transmission medium reducing transmission impairments.
Pulse Modulation	A _____ is simply the superposition of a series of harmonically related sine waves with specific amplitude and phase relationships.
Crosshairs	The decision levels for the regenerator are represented by
Jitter	The _____ has an effect on the symbol timing (clock) recovery circuit and, if excessive, may significantly degrade the performance of cascaded regenerative sections.

CHAPTER 11: DIGITAL T-CARRIERS AND MULTIPLEXING

TERMS	DEFINITION
Multiplexing	Transmission of information from one or more source to one or more destination over the same transmission medium (facility).
Space-Division Multiplexing	Unsophisticated form of multiplexing that simply constitutes propagating signals from different sources of different cables that are contained within the same trench.
Trench	Considered as transmission medium.
QPSK	Form of phase-division multiplexing (PDM) where two data channels (the I and Q) modulate the same carrier frequency that has been shifted 90° in phase.
I – Channel Bits	Modulates a sine wave carrier.
Q – Channel Bits	Modulates a cosine wave carrier.
<p>Three most predominant methods of multiplexing signals.</p> <ul style="list-style-type: none"> ➤ Time-Division Multiplexing ➤ Frequency-Division Multiplexing ➤ Wavelength-Division Multiplexing 	
Time-Division Multiplexing	Transmissions from multiple sources occur on the same but not on the same time.
PCM	Most prevalent encoding technique used for TDM digital signals.
DS-O Channel	Use an 8-kHz sample rate and an eight-bit PCM code, which produces a 64 kbps PCM line speed.
Multiplexer	Simply an electronically controlled digital switch with two inputs and one output.
TDM Frame	One eight-bit PCM code from each channel (16 total bits).
Frame Time	Time it takes to transmit one TDM frame.
Digital Carrier System	A communications system that uses digital pulses rather than analog signals to encode information.
T1 or Transmission One	Specifies a digital carrier system using PCM encoded analog signals.
T1 Lines	Special conditioned cables.
Framing Bit	Used to maintain frame and sample synchronization between TDM transmitter & receiver.

Digital Channel Banks	PCM encoders & decoders with a seven-bit magnitude.
Signaling	Supervision between telephone offices, such as on hook, off hook, dial pulsing, and so forth.
Signaling Frame	Only seven-bit resolution.
Extended Super Frame Format	Consist of 24 193 bit frames, totaling 4632 bits, of which 24 are framing bits.
CRC-6 (Cyclic Redundancy Checking)	It is used for an error detection code.
Signaling Channels	These signaling bits streams are sometimes called A, B, C and D.
Fractional T Carrier	It emerged because standard T1 carriers provide a higher capacity than most user require.
384 kbps	The minimum data rate necessary to propagate video information?
Data Service Unit / Channel Service Unit	Digital interface that provides the physical connection to a digital carrier network.
Multiplexers / Demultiplexers	Upgrade from one level in the hierarchy to the next higher level.
Digital Cross Connect	Provides a convenient place to make patchable inter connects and perform routine maintenance & trouble shooting.
Signal Processor	Provides frequency shifting for the master group signals and dc restoration for the television signal.
Picturephone	It is a low quality video transmission for use between non-dedicated subscribers.
Three-Bit Code	Identify when transitions occur in the data and whether that transition is from a 1 to a 0 or vice versa.
<p style="text-align: center;">Three-Bit Code</p> <ul style="list-style-type: none"> ➤ 1st bit = Address bit ➤ 2nd bit = the transition occurred during 1st half (0) or during the 2nd half (1) ➤ 3rd bit = indicates the sign or direction of the transition. 	
Digital Line Encoding	Converting standard logic levels to a form more suitable to telephone line transmission.
<p style="text-align: center;">Six Primary Factors must be considered when selecting a line encoding format</p> <ul style="list-style-type: none"> ➤ Transmission voltages and DC component ➤ Duty Cycle ➤ Bandwidth considerations ➤ Clock and Framing bit recovery ➤ Error Detection 	

➤ Ease of detection and decoding	
Transmission voltages	It can be categories as being unipolar or bipolar.
Unipolar	Involves the transmission of only a single nonzero voltage level.
Bipolar	Two nonzero voltages are involved (a positive voltage for a logic 1 and an equal-magnitude negative voltage for a logic 0 or vice versa).
Duty Cycle	It is a binary pulse can be used to categorize the type of transmission.
Nonreturn to Zero	If the binary pulse is maintained the entire bit time, this is called?
Return to Zero	If the active time of the binary pulse is less than 100% of the bit time, this is called?
DC Wandering	Produces a condition in which a receive may lose its amplitude reference for optimum discrimination between received 1's & 0's.
Digital Biphase	Popular type of line encoding that produces a strong timing component for clock recovery and does not cause dc wandering.
Manchester Code or Diphase	Digital Biphase is sometimes called?
Biphase	Uses one cycle of a square wave at 0° phase to represent logic 1 and one cycle of a square wave at 180° phase to represent logic 0.
Biphase M	Used for encoding SMPTE(Society of Motion Picture and Tele vision Engineers) time-code data for recording on videotapes.
Biphase L	Commonly called the Manchester Code and specified in IEEE standard 802.3 for Ethernet local area networks.
Miller Codes	Forms of delay-modulated codes where a logic 1 condition produces a transition in the middle of the clock pulse, and a logic 0 produces no transition at the end of the clock intervals unless followed by another logic 0.
T Carriers	Used for the transmission of PCM-encoded time-division multiplexed digital signals.
Amplifier / Equalizer	Filters and shapes the incoming digital signal and raise its power level so that the regenerator circuit can make a pulse-no pulse decision.
Timing Clock	Recovery circuit reproduces the clocking information from the received data and provides the proper timing information to the regenerator so that samples can be made at the optimum time, minimizing the chance of an error occurring.
Regenerative Repeater	A threshold detector that compares the sampled voltage received to a reference level and determines whether the bit is a logic 1 or a logic 0.
T1 Carrier Systems	This system is designed to combine PCM and TDM techniques for short-haul transmission of 24 64-kbps channels with each capable of carrying digitally encoded voice-band telephone signals or data.

T1 Carrier	It has a transmission bit rate of 1.544Mbps, including an 8-kbps framing bit. And has a length of range from about 1 mile to over 50 miles.
Ones Density	It ensured that sufficient transition occur in the data stream is sometimes called?
A1	It is substituted into the second least significant bit, which introduces an encoding error equal to twice the amplitude resolution.
Binary Eight Zero Substitution (B8ZS)	It ensures that sufficient transitions occur in the data to maintain clock synchronization.
T2 carrier system	The carrier time division multiplex 96 64 kbps voice or data channel into a single 6.312 Mbps data signal for transmission over twisted- pair copper wire up to 500 miles over a special LOCAP (Low Capacitance) metallic cable.
Binary Six Zero Substitution (B6ZS)	T2 carrier system uses an alternative method of ensuring that amplitude transition occurs in the data.
T3 carrier system	The carrier time division multiplex 96 64 kbps voice or data channel for transmission over a single 3A-RDS coaxial cable and it has a bit rate of 44.736 Mbps.
Binary Three Zero Substitution (B3ZS)	The coding technique use in T3 carrier system is called?
E-Lines	Different version of T carriers used in Europe.
Time Slot 0	Used for frame alignment pattern and for an alarm channel.
<p style="text-align: center;">Digital carrier frame synchronization</p> <ul style="list-style-type: none"> ➤ Added-Digit Framing ➤ Robbed-digit framing ➤ Added-channel framing ➤ Statistical framing ➤ Unique-line code framing 	
Bit Interleaving & Word Interleaving	The two methods of Interleaving PCM transmissions are?
Statistical Time-Division Multiplexing	Used more often for the transmission of data when they are called asynchronous TDM, intelligent TDM, or simply stat muxs.
CODEC	Large-scale integration (LSI) chip designed for use in the telecommunications industry for private branch exchanges.
<p style="text-align: center;">Three functions of codec</p> <ul style="list-style-type: none"> ➤ Analog Sampling ➤ Encoding / Decoding ➤ Digital Companding 	

Combo Chips	It can provide the analog-to-digital and digital-to-analog conversions and the transmit and receive filtering necessary to interface a full-duplex voice telephone circuit to the PCM highway of a TDM carrier system.
<p style="text-align: center;">General Operations of Combo Chips</p> <ul style="list-style-type: none"> ➤ Bandpass filtering of the analog signals prior to encoding and after decoding ➤ Encoding and decoding of voice and call progress signal ➤ Encoding and decoding of signaling and supervision information ➤ Digital companding 	
Time Slot Strobe Buffer	Used to gate the PCM word onto the PCM highway when an external buffer is used to drive the line.
Burst Mode	Data are input and output for a single channel in a short burst.
Variable-Data-Rate Mode	Allows for a flexible data input and output clock frequency.
Shift Register Mode	Data from the PCM highway are clock into the codec on the next eight consecutive negative transitions of DCLKR.
Supervisory Signaling	It can be used only in the fixed-data-rate mode.
Frequency Division Multiplexing	Multiple sources that originally occupied the same frequency spectrum are each converted to a different frequency.
Stacking	The process which accomplished without synchronization between stations.
Short Haul; Long Haul	AT&T's communications network is subdivided into 2:
Message Channel	Basic building block of the FDM Hierarchy.
Group	It is the next higher level in the FDM hierarchy above the basic message channel and consequently, is the first multiplexing step for combining messages channels.
Basic Supergroup	It is formed by frequency-division multiplexing five groups containing 12 channels each for a combined bandwidth of 240 kHz (5 groups x 48 kHz / group or 5 groups x 12 channel groups x 4kHz/ channel).
Basic Mastergroup	It is formed by frequency-division multiplexing 10 supergroups together for a combined capacity of 600 voice-band message channel occupying a bandwidth of 2.4 MHz (600 channels x 4kHz/channel or 5 groups x 12 channels/groups x 10 groups/supergroups).
Larger Groupings	Basic Mastergroup can be further multiplexed in mastergroup banks to form jumbogroup (3600 VB channels), multijumbogroup (7200 VB channels) and superjumbo group (10800 VB channels).
Baseband	It described the modulating signal in the communication system.
Composite Band	It is the final output of the FDM multiplexer.

Guard Band	These are necessary because the demultiplexing process is accomplished through filtering and down converting.
Quality Factor	The guard band reduces the _____ which is required to perform the necessary filtering.
Radio Channel	It comprises either a single L600 mastergroup or up to three U600 mastergroup (1800 voice-band channels)
Wavelength Division Multiplexing	Is a network mechanism for telecommunications routing, switching and selection based on the wavelength begins a new era in optical communications.
Demultiplexers / Splitters	Separate signals with different wavelengths in a manner similar to the way filter separate electrical signals of different frequencies.
Add / Drop Multiplexers / Demultiplexers	Similar to regular multiplexers and demultiplexers except they are located at intermediate points in the system.
WDM Routers	Direct signals of a particular wavelength to a specific destination while not separating all the wavelengths present on the cable.
WDM Couplers	Enable more efficient utilization of the transmission capabilities of optical fibers by permitting different wavelengths to be combined and separated.
<p style="text-align: center;">Three basic types of WDM couplers</p> <ul style="list-style-type: none"> ➤ Diffraction Grating ➤ Prism ➤ Dichroic Filter 	
Diffraction Gating or Prism	The specific wavelength is separated from the other optical signal by reflecting them at different angles.
Dichroic Filter	It is a mirror with a surface that has been coated with a material that permits the lights of only one wavelength to pass through while reflecting all other wavelengths.
Synchronous Optical Network	Multiplexing system similar to conventional time division multiplexing.
STS-1 (Synchronous Transport level 1)	Has a 51.84-Mbps synchronous frame structure.
OC-48	Second level of SONET multiplexing.

CHAPTER 12: METALLIC CABLE MEDIA TRANSMISSION

TERMS	DEFINITIONS
Guided Transmission Media	Provides a conduit in which electromagnetic signals are contained.
Unguided Transmission Media	Emitted then radiated through air or a vacuum.
Cable Transmission Medium	Used to propagate electromagnetic signals between two locations in a communications system.
Cable Transmission Systems	Most common means of interconnecting devices in local area networks.
Transmission line	Metallic conductor system used to transfer electrical energy from one point to another using electrical current flow.
longitudinal and transverse	Two basic kinds of waves.
Frequency	The rate at which the periodic wave repeats.
Metallic circuit currents	Currents that flow in opposite directions in a balanced wire pair.
Longitudinal currents	Currents that flow in the same direction.
Common mode rejection	Cancellation of common mode signals.
Single-ended or unbalanced	One wire is at the ground potential, whereas the other is at signal potential.
balun	A circuit device used to connect a balanced

	transmission line to an unbalanced load.
Parallel-conductor transmission lines and coaxial transmission lines.	Most common metallic cables used to interconnect data communications systems and computer networks.
Twisted-pair	Formed by twisting two insulated conductors around each other.
Unshielded twisted pair and Shielded twisted pair	Types of twisted pair.
Near-end crosstalk	Coupling that takes place when a transmitted signal is coupled into the received signal at the same end of the cable.
Pair 1: blue/white stripe and blue Pair 2: orange/white stripe and orange Pair 3: green/white stripe and green Pair 4: brown/white stripe and brown	Standard color code specified by the EIA for CAT-5 cable.
Braid	Woven into a mesh.
Plenum	Name given to the area between the ceiling and the roof in a single-story building or between the ceiling and the floor of the next higher level in a multi-story building.
Coaxial	Used for high data transmission rates to reduce losses and isolate transmission path.
Shielding	Refers to the woven stranded mesh that surrounds some types of coaxial cables.

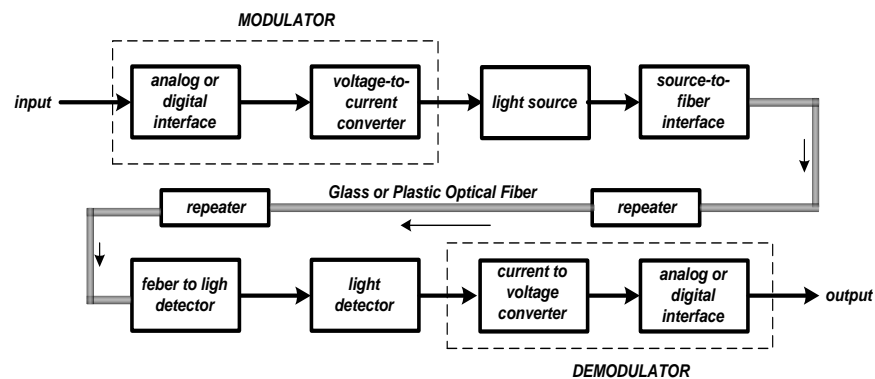
Dual shielded	One layer of foil insulation and one layer of braided shielding.
Rigid air-filled; solid flexible	Types of coaxial cables.
Distributed parameters	Uniformly distributed throughout the length of the line.
Secondary constants	Transmission characteristics of a transmission line.
Surge impedance	Impedance seen looking into an infinitely long line.
Propagation constants	Expressed the attenuation and the phase shift per unit length of a transmission line.
Velocity factor.	Ratio of the actual velocity of propagation of an electromagnetic wave through a given medium to the velocity of propagation through a vacuum.
Dielectric constant	Relative permittivity of a material.
Conductor loss, radiation loss, dielectric heating loss, coupling loss and corona	Several ways in which signal power is lost.
Incident voltage	Voltage that propagates from the source toward the load.
Reflected voltage	Voltage that propagates that propagates from the load toward the source.
Flat or non	

resonant line	Transmission line with no reflected power.
Reflection coefficient	Vector quantity that represents the ratio of reflected voltage to incident voltage or reflected current to incident current.
Matched line	Incident power is absorbed by the load.
Unmatched or mismatched line	Incident power returned (reflected) to the source.
Standing wave	Two travelling waves set up an interference pattern.
Standing-wave ratio	Ratio of the maximum voltage to the minimum voltage or the maximum current to the minimum current of a standing wave on a transmission line.
Quarter-wavelength transformers	Used to matched transmission lines to purely resistive loads whose resistance is not equal to the characteristic impedance of the line.
Time domain reflectometry (TDR)	A technique that can be used to locate an impairment in a metallic cable
Echo	Return signal.
Microstrip	Simply a flat conductor separated from a ground plane by an insulating di-electric material.
Stripline	Simply a flat conductor sandwiched between two ground planes.

CHAPTER 13: OPTICAL FIBER TRANSMISSION MEDIA

TERMS	DEFINITION
Fiber Optics	A branch of optics that deals with communication by transmission of light through ultrapure fibers of glass or plastic.
Fiber Optic System	Is a communications system that carries information through a guided fiber cable.
Optical Fiber	Dielectric waveguide used for the propagation of electromagnetic energy at optical frequencies.

Optical Fiber communication Link



Analog / Digital Interface	It matches impedance and limits input signal amplitude.
Voltage to Current Converter	It serves as an electrical interface between input circuitry and light source.
Light Source	It is either an LED (light Emitting Diode) or ILD (Injected Laser Diode); amount of light emitted is proportional to the amount of drive current.
Source to Fiber Interface	A mechanical interface; couples light into the optic fiber cable.
Fiber-to-Light Detector	A mechanical coupler; couples as much light as possible from the fiber cable into the light detector.
Light Detector	It's either a PIN diode or an APD (Avalanche Photodiode); both convert light energy to current.
Current to Voltage Converter	It transforms changes in detector current to changes in output signal voltage.
Analog or digital Interface	It is an electrical interface; matches impedance and signal levels to the output circuitry.
Information-Carrying Capacity	Electronic communications system is directly proportional to bandwidth.
Bandwidth	It is common to express the bandwidth of an analog communications system

Utilization Ratio	as a percentage of its carrier frequency.
Photophone	Device constructed from mirrors and selenium detectors that transmitted sound waves over a beam of light.
Alexander Graham Bell	He experimented with an apparatus called photophone.
Flexible fiberscope	Used extensively in medical field.
Laser (light amplification by stimulated emission of radiation)	Invented in 1960, which relatively high output power, high frequency of operation, and capability of carrying an extremely wide bandwidth signal make it ideally suited for high-capacity communications system.
Karpon, Keck and Maurer	In 1970, they developed an optical fiber with losses less than 2dB/km.

Three Regions of Optical Fiber

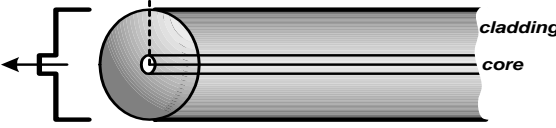
1. **Core** – a transmission area of the fiber; typical diameters: 50 to 500 μm .
2. **Cladding** – surrounds the core, has a different index of refraction; defines the optical boundary of the core and makes sure that the total internal reflection occurs at the core outer skin.
3. **Coating** – specially formulated plastic coating that provides a first level shock and abrasion resistance for the fiber; typical thickness is 250 μm to 1000 μm .

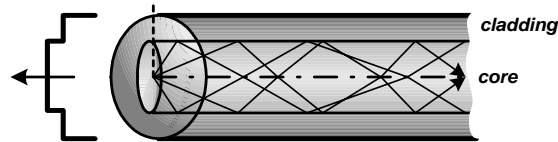
Types of Optical Fiber

1. **Plastic Core and Cladding**
 - Flexibility and ruggedness
 - Easy to install
 - Less Weight
 - More economical
 - Can withstand stress
 - High attenuation
 - Inefficient
 - Limited for short distance applications
2. **Glass core with plastic cladding (PCS; Plastic Clad Silica)**
 - Less affected by radiation
 - Attractive to military applications
3. **Glass core and glass cladding (SCS fiber; Silica-Clad Silica)**
 - Susceptible to increase in attenuation when exposed to radiation
 - Least rugged
 - Easier to terminate

Advantages of Optical Fiber cables.

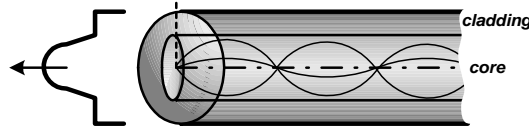
1. wider bandwidth and greater information capacity
2. immunity to crosstalk
3. immunity to statistic interference
4. environmental immunity
5. safety and convenience
6. lower transmission loss
7. security

8. durability and reliability 9. economics	
<p style="text-align: center;">Disadvantages of Optical Fiber cables.</p> 1. interfacing cost 2. strength 3. remote electrical power 4. optical fiber cables are more susceptible to losses introduced by bending the cable 5. specialized tools, equipment, and training	
Stress corrosion	Reduces the possibility of the occurrence of a detrimental phenomenon.
Buffer jacket	Protective coating and which provides the additional protection against abrasion and shocks.
Strength member	Increases the tensile strength of the overall cable assembly.
Plank's Law	It described the photoelectric effect, which state, "When visible lights or high frequency electromagnetic radiation illuminates a metallic surface, electrons are emitted".
mode (path) of propagation	A stable propagation state in an optical fiber. The number of modes a fiber can transmit depend on its numerical aperture as well as the wavelength.
Index Profile	A graphical representation of the refractive index of the core.
<p style="text-align: center;">Classifications of Optical Fibers</p> <p>1. Single Mode (Monomode)</p> <ul style="list-style-type: none"> ➤ Only one path for light to take down the cable. ➤ Core diameter of a single mode fiber is extremely small (2 to 4um diameter). ➤ Extremely wide bandwidths and low losses. This gives the highest and longest distances but it requires powerful and precisely aligned light sources. <div style="text-align: center;">  </div> <p>2. Multimode Fibers</p> <ul style="list-style-type: none"> ➤ The light wave rays take many paths between the source and the far end of the fiber. ➤ The fiber core diameter must be large enough to permit propagation in several modes. ➤ Since some paths are longer than the others, the original sharp pulse at the source is spread out in time at the receiver. This pulse spreading reduces the bandwidth and the maximum data rate of the system. <p>Two Types:</p> <p>a. Step Index</p> <ul style="list-style-type: none"> ➤ The core has a uniform index of refraction providing an abrupt change in refraction index at the core-cladding interface. ➤ These types of fibers have relatively high dispersion making it useful only at lower rates and shorter distance. 	



b. Graded Index

- The core has index of refraction that changes continuously from the center to the outside.
- This core is made out of many thin layers, each with lower index of refraction than the adjacent inner one. The effect of this grading is that light waves are propagated by refraction so they are bent in a sinusoid like curve about the fiber.



Spontaneous decay or spontaneous emission	Process of decaying from one energy level to another energy level.
Absorption	The process of moving from one energy to another energy level is called?
Photometry	Science of measuring only light waves that are visible to human eye.
Light Intensity	It is a complex concept that can be expressed in either photometric or radiometric terms.
Optical power	Measures the rate at which electromagnetic waves transfer light energy.
Radian Flux	It is the equivalent to joule per second and is the power that is measured electrically or thermally in watts.
Prismatic Refraction	This phenomenon that cause rainbows, where water droplets in the atmosphere act as a small prism that split the white sunlight into the various wavelength, creating a visible spectrum of color.
Refractive index	Simply the ratio of velocity of propagation of a light ray in free space to the velocity of propagation of a light ray in a given material.

The refractive index (η)

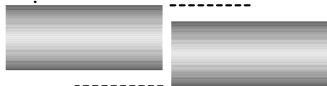

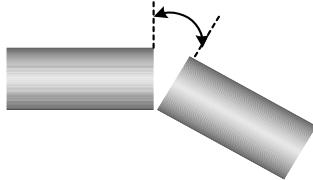
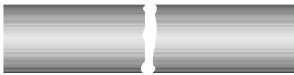
$$\eta = \frac{c}{v}$$

MEDIUM	η
Vacuum	1.0
Air	1.00029
Water	1.33
Ethyl Alcohol	1.36
Fused Quartz	1.46

	Glass Fiber	1.5 – 1.9
	Diamond	2.0 – 2.42
	Silicon	3.4

Snell's law	<p>It explains how a light may react when it meets the interface of two transmissive materials that have different indices of refraction using the law which states that:</p> $\eta_1 \sin \theta_1 = \eta_2 \sin \theta_2$ <p>where: η_1 = refraction index of material 1 η_2 = refraction index of material 2 θ_1 = angle of incidence θ_2 = angle of refraction</p> <ul style="list-style-type: none"> ➤ When a light travels from a less dense material into a more dense material, the wave is refracted towards the normal. ➤ When a light ray enters a less dense material, the ray bends away from the normal.
Normal	It is simply a line drawn perpendicular to the interface at the point where the incident ray strikes the interface.
Angle of incidence	Angle at which the propagating ray strikes the interface with respect to the normal.
Angle of refraction	Angle formed between the propagating ray and the normal after the ray has entered the second medium.
Critical Angle	<p>It is defined as the minimum angle of incidence at which a light ray may strike the interface of the two media and result in a angle of refraction of 90 degrees or greater.</p> $\theta_c = \sin^{-1} \frac{\eta_2}{\eta_1}$ <p>where: $\eta_2 < \eta_1$</p>

Acceptance Angle or Acceptance Cone Half Angle (θ_{in})	<p>Maximum angle in which external light rays may strike the air/fiber interface and still propagate down fiber.</p> $\theta_{in} = \sin^{-1} \sqrt{\eta_1^2 - \eta_2^2}$
Numerical aperture	<p>A figure of merit used to measure the light gathering or light collecting ability of the optical fiber.</p> $NA = \sin \theta_{in}$ $NA = \sqrt{\eta_1^2 - \eta_2^2}$
V Parameter (V)	<p>It is a key parameter that describes the mode structure of a fiber.</p> $V = \frac{2\pi a}{\lambda} \eta_1 \sqrt{2\Delta} ; \text{multimode} \quad V = 2.405 \sqrt{1 + \frac{2}{g}} ; \text{single-mode}$ <p>where:</p> $\Delta = \frac{\eta_1^2 - \eta_2^2}{2\eta_1^2} ; \text{fractional change in the index of refraction of multimode-mode step index}$ $\Delta = \frac{\eta_1 - \eta_2}{\eta_1} ; \text{fractional change in the index of refraction of multimode-mode graded index}$ <p> a = radius of the core of the fiber λ = wavelength η_1 = index of refraction of core η_2 = index of refraction of cladding g = gradient of graded fiber $= 2$; parabolic profile $= 1$; triangular profile $= \infty$; step index profile </p>
Number of Modes (N)	$N = \frac{V^2}{2} ; V \gg 2.405 \text{ (for multimode step index)}$ $N = \left(\frac{g}{g+2} \right) \left(\frac{V^2}{2} \right) ; \text{for multimode graded index}$
Scattering Losses	This is due to imperfections in the fiber that are formed during manufacturing process. Cooling process of glass irregularities, imperfections such as tiny bubbles, and imperfections in the internal uniformity causing light rays to be diffracted (dispersed) or to escape.
Linear scattering	The power transferred from a wave is proportional to the power of the wave.
Rayleigh Scattering	The light interacting with inhomogeneities in the medium that are much smaller than the wavelength of the light.
Mie Scattering	Inhomogeneities that is comparable in size to a wavelength.
Nonlinear Scattering	Significant power to be scattered in the forward, backward, or sideways directions, depending on the nature of the interaction.
Brillouin Scattering	Modulation of the light by the thermal energy in the material. The incident photon of light undergoes the nonlinear interaction to produce vibrational energy (phonons) in the glass as well as scattered light (as photons).
Raman Scattering	The nonlinear interaction produces a high-frequency phonon and a scattered photon.
Absorption Losses	Impurities in the fiber absorb the light and convert it to heat.

Types Of Absorption Loss	
<ul style="list-style-type: none"> ➤ Ultraviolet Absorption – light ionizes the valence electrons into conduction; ionization is equivalent to a loss in the light field. ➤ Infrared Absorption – photons of light absorbed by atoms of the glass core are converted to mechanical vibrations typical of heating. ➤ Ion Resonance absorption – caused by OH⁻ ions from water molecules trapped in the glass during manufacturing process. 	
Dispersion	Spreading of pulse out in the time domain, changing its shape so that it may merge into the previous and succeeding pulses. The pulses maybe separated by spacing them out at the transmitter but this means reducing the maximum bit rate.
Types of Dispersion	
<ul style="list-style-type: none"> ➤ Material or Chromatic or Wavelength Dispersion – light sources emit light that contains a combination of wavelengths. Therefore, different wavelengths do not arrive at the same. ➤ Waveguide Dispersion – attributed to the dependence of the phase and group velocities on the geometric characteristic of the waveguide. ➤ Modal Dispersion – it is caused by the different path lengths associated with each of the modes of a fiber. Caused by the difference in the propagation times of light rays that take different path down a fiber; occur only in multimode fibers. A portion of the light energy traveling in the cladding. 	
Coupling Losses	
1. Lateral Misalignment	
2. Gap Misalignment or Longitudinal Displacement	
3. Angular Misalignment	
4. Imperfect Surface Finish	
Light Sources	A light source is any material or device which gives off energy with a wavelength from about 300 microns down to 0.5 microns.
Requirement of Light Source	

<ul style="list-style-type: none"> ➤ Their light must be as nearly monochromatic (single frequency) as possible. ➤ Capable of being easily modulated; PCM for better noise immunity ➤ High intensity light output so that sufficient energy is transmitted to overcome the losses encountered during transmission down the fiber. ➤ Devices should be small, compact, and easily couple to the fibers so that excessive coupling losses do not occur. ➤ Must be inexpensive to manufacture 	
Light Emitting Diodes (LED)	<ul style="list-style-type: none"> ➤ Non-coherent injection light sources which are low-cost, low heat light sources and are the most promising light sources for optical transmission. ➤ LEDS have the necessary reliability, life expectancy, and simplicity for optical transmission purposes. ➤ It emits light over a rather large angle thus coupling less power into the fiber. ➤ LEDS are able to couple about 100uW of power with a coupling efficiency of 2%.
Injection Laser Diodes (ILD)	ILDs make the most efficient use of electric energy. This coherent light source can couple a few milliwatts of light power into a fiber since it has a more direct radiation pattern.
<p style="text-align: center;">Advantages of ILDs over LED</p> <ul style="list-style-type: none"> ➤ Reduced coupling losses ➤ Greater radiant output power ➤ Can be used at higher bit rates ➤ Reduced wavelength dispersion; monochromatic <p style="text-align: center;">Disadvantages of ILD's</p> <ul style="list-style-type: none"> ➤ Expensive ➤ Shorter lifetime ➤ Temperature dependence ➤ Requires automatic level control circuit to protect the device from power Supply transients: 	
Homojunction LED's	A p-n junction made from two different mixtures of the same types of atoms is called?
Epitaxially grown	Generally constructed of silicon-doped gallium-arsenide.
Planar diffused	Homojunction LED's output approximately 500 μ at a wavelength of 900 nm.
Heterojunction LED's	This are made from p-type semiconductor material of one set of atom and an n-type semiconductor material from another set.
Edge Emitters	The light emitted from the edge of the material is called?
Planar Heterojunction LED	It is quite similar to the epitaxially grown LED except that the geometry is designed such that the forward current is concentrated to a very small area of the layer.

<p align="center">Advantages of heterojunction devices over homojunction devices</p> <ul style="list-style-type: none"> ➤ Increase in current density generates a more brilliant light spot. ➤ Smaller emitting area makes it easier to couple its emitted light into a fiber. ➤ Small effective area has a smaller capacitance, which allows the planar heterojunction LED to be used at a higher speed. 	
PIN diode	Depletion-layer photo diode and is probably the most common device used as a light detector in fiber optic communications system.
<p align="center">Light Detectors</p> <ul style="list-style-type: none"> ➤ PIN (Positive Intrinsic Negative) diodes - When photons are absorbed by intrinsic layer's electrons in the valence band, they add sufficient energy to generate carriers in the depletion region and allow current to flow thru the device. ➤ APD (Avalanche Photo Diode) - Light enters diode and is absorbed by the thin, heavily doped n-layer causing a high electric field intensity to be across i-p-n junction thus ionization occur and continues like avalanche. 	
<p align="center">Advantages of APD over PIN</p> <ul style="list-style-type: none"> ➤ APD's give better sensitivity over PIN ➤ APD's provides larger amplification <p align="center">Disadvantages of APD</p> <ul style="list-style-type: none"> ➤ High bias requirement ➤ Temperature dependence ➤ Long transit time 	
<p align="center">Characteristic of a light detector.</p> <ul style="list-style-type: none"> ➤ Responsivity ➤ Dark currents ➤ Transit time ➤ Spectral response ➤ light sensitivity 	
Laser	Technology deals with the connection of light into a very small, powerful beam.
<p align="center">Types of Laser</p> <ul style="list-style-type: none"> ➤ Gas Laser – use a mixture of helium and neon enclosed in a glass tube. ➤ Liquid Laser – use organic dyes enclosed in a glass tube for an active medium. ➤ Solid Laser – use a solid cylindrical crystal, such as ruby, for the an active medium. ➤ Semiconductor Laser – are made from semiconductor p-n junction and are commonly called ILDs. 	
<p align="center">Optical Fiber System Link Budget</p> <ul style="list-style-type: none"> ➤ Cable Losses – it depends on the cable length, material and material impurity. 	

- **Connector Losses** – if mechanical connection is not perfect, light energy can escape, resulting in a reduction of optical power.
- **Source to Cable Interface Loss** – the mechanical interface used to house the light source and attach it to the cable is seldom perfect.
- **Cable to Light Detector Interface Loss** - the mechanical interface used to house the light source and attach it to the cable is also not perfect and therefore, prevent a small percentage of power leaving the cable from the entering the light detector.
- **Splicing Loss** – if more than one continuous section of cable is required, cable section can be fused together.
- **Cable Bend** – when an optical cable is bend at too large an angle, the characteristics of the cable can change dramatically.

CHAPTER 14: ELECTROMAGNETIC WAVE PROPAGATION

Free-space	Propagation of electromagnetic waves often called radio-frequency (RF) propagation or simply radio propagation.
Electromagnetic wave	Electrical energy that has escaped into free space.
Polarization	The orientation of the electric field vector in respect to the surface of the Earth.
Linear Polarization	Polarization remains constant
Horizontal Polarization and Vertical Polarization	Forms of Linear polarization
Circular Polarization	Polarization vector rotates 360° as the wave moves one wave-length through the space and the field strength is equal at all angles of polarization.
Elliptical Polarization	Field strength varies with changes in polarization.
Rays	Used to show the relative direction of electromagnetic wave propagation.
Wavefront	Formed when two points of equal phase on rays propagated from the same source are joined together.
Point source	A single location from which rays propagate equally in all directions.
Magnetic Field	Invisible force field produced by a magnet, such as a conductor when

	current is flowing through.
Strength of a magnetic field (H)	$H = 1/2 \mu d$
Electric fields	Invisible force fields produced by a difference in voltage potential between two conductors.
Electric field strength (E)	$E = q/4 \pi \epsilon d^2$
Permittivity	Dielectric constant of the material separating the two conductors.
Permittivity of air or free space	$8.85 \times 10^{-12} \text{ F/m}$
Power density	The rate at which energy passes through a given surface area in free space.
Field intensity	Intensity of the electric and magnetic fields of an electromagnetic wave propagating in free space.
Power density	$P = \epsilon H \text{ W/m}^2$
Characteristic Impedance	It is equal to the square root of the ratio of its magnetic permeability to its electric permittivity. $Z_s = (\mu_0/\epsilon_0)^{1/2}$
Isotropic radiator	Point source that radiates power at a constant rate uniformly in all directions.
Inverse Square Law	Power density is inversely proportional to the square of the distance from the source.
Isotropic medium	Propagation medium.
Attenuation	Waves propagate through free space; they spread out, resulting in a reduction in power density.
Absorption Loss	Reduction of Power.
Wave attenuation	Reduction in power density with distance is equivalent to a power loss.
Space attenuation	Spherical spreading of the wave.
Homogeneous medium	One with uniform properties throughout.
Inhomogeneous medium	Absorption coefficient varies considerably with location, thus creating a difficult problem for radio systems engineers.

Refraction, Reflection, Diffraction and Interference	Optical properties of Radio Waves.
Refraction	Bending of the radio wave path.
Refractive index; $n = (k)$	Square root of the dielectric constant and is expressed in:
Equivalent dielectric constant	Relative to free space (vacuum). $K = (1 - 81N/f^2)^{1/2}$
Plane	Boundary between two media with different densities.
Normal	Imaginary line drawn perpendicular to the interface at the point of incidence.
Angle of Incidence	Angle formed between the incident wave and the normal.
Angle of Refraction	Angle formed between the refracted wave and the normal.
Refractive Index	Ratio of velocity of propagation of a light ray in free space to the velocity of propagation of a light ray in a given material.
Density gradient	Perpendicular to the direction of propagation (parallel to the waveform)
Reflect	To cast or turn back.
Reflection Coefficient	Ratio of the reflected to the incident voltage intensities.
Power transmission coefficient	Portion of the total incident power that is not reflected.
Absorption coefficient	Fraction of power that penetrates medium 2.
Diffuse reflection	Incident wave front strikes an irregular surface, it is randomly scattered in many directions.
Specular (mirrorlike) reflection	Reflection from a perfectly smooth surface.
Semirough surfaces	Surfaces that falls between smooth and irregular.
Rayleigh criterion $\cos \theta_i > \lambda/8d$	Semirough surface will reflect as if it were a smooth surface whenever the cosine of the angle of incidence is greater than $\lambda/8d$, where d is the depth of the surface irregularity and λ is the wavelength of the incident wave.

Diffraction	Modulation or redistribution of energy within a wavefront when it passes near the edge of an opaque object.														
Shadow zone	Diffraction occurs around the edge of the obstacle, which allows secondary waves to “sneak” around the corner of the obstacle.														
Linear Superposition	States that the total voltage intensity at a given point in space is the sum of the individual wave vectors.														
Terrestrial waves	Electromagnetic waves travelling within Earth’s atmosphere.														
Terrestrial radio communications	Communications between two or more points on Earth.														
Sky waves	Used for high-frequency applications.														
Surface wave	Earth –guided electromagnetic wave that travels over the surface of earth.														
<table><tr><td>Surface</td></tr><tr><td>Seawater</td></tr><tr><td>Flat, loamy soil</td></tr><tr><td>Large bodies of freshwater</td></tr><tr><td>Rocky terrain</td></tr><tr><td>Desert</td></tr><tr><td>Jungle</td></tr></table>	Surface	Seawater	Flat, loamy soil	Large bodies of freshwater	Rocky terrain	Desert	Jungle	<table><tr><td>Relative Conductivity</td></tr><tr><td>Good</td></tr><tr><td>Fair</td></tr><tr><td>Fair</td></tr><tr><td>Poor</td></tr><tr><td>Poor</td></tr><tr><td>Unusable</td></tr></table>	Relative Conductivity	Good	Fair	Fair	Poor	Poor	Unusable
Surface															
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Jungle															
Relative Conductivity															
Good															
Fair															
Fair															
Poor															
Poor															
Unusable															
Relative Conductivity of Earth Surfaces															
Disadvantages of surface waves.	1. Ground waves require a relatively transmission power. 2. Ground waves are limited to very low, low, and medium frequencies. 3. Requiring large antennas. 4. Ground losses vary considerably with surface material and composition.														
Advantages of ground wave propagation.	1. Given enough transmit power, ground waves can be used to communicate between any two locations in the world. 2. Ground waves are relatively unaffected by changing atmospheric														

	conditions.
Direct waves	Travel essentially in a straight line between the transmit and receive antennas.
Line-of-Sight (LOS) transmission	Space wave propagation with direct waves.
Radio Horizon	The curvature of Earth presents a horizon to space wave propagation.
Duct propagation	Occurs when the density of the lower atmosphere is such that electromagnetic waves are trapped between it and Earth's surface.
D Layer	Lowest layer of the ionosphere and is located approximately between 30 miles and 60 miles (50 km to 100 km) above Earth's surface.
E Layer	Located approximately between 60 miles and 85 miles (100 km to 140 km) above Earth's surface.
Sporadic E layer	The upper portion of the E layer.
F Layer	Made up of two layers, F 1 and F 2 layers.
Critical frequency	Highest frequency that can be propagated directly upward and still be returned to Earth by the ionosphere.
Critical Angle	Maximum vertical angle at which it can be propagated and still be refracted back by the ionosphere.
Ionospheric Sounding	A measurement technique used to determine the critical frequency.
Virtual Height	Height above the Earth's surface from which a refracted wave appears to have been reflected.
Maximum Usable Frequency (MUF)	Highest frequency that can be used for sky wave propagation between two specific points on Earth's surface.
Secant law	$MUF = \text{critical frequency} / \cos \theta_i$
Optimum Working Frequency (OWF)	Operating at a frequency of 85% of the MUF provides more reliable communications.
Skip distance	Minimum distance from a transmit antenna that a sky wave at a given frequency will be returned to Earth.
Quiet, or skip, zone	The area between where the surface waves are completely dissipated and the point where the first sky wave returns to Earth.

Ceiling	Formed by the ionosphere is raised, allowing sky waves to travel higher before being returned to Earth.
Free-space path loss	Define as the loss incurred by an electromagnetic waves as it propagates in a straight line through a vacuum with no absorption or reflection of energy from nearby objects.
Spreading loss	Occurs simply because of the inverse square law.
Fading	Variation in signal loss.

CHAPTER 15: ANTENNAS AND WAVEGUIDES

TERMS	DEFINITION
Antenna	A metallic conductor system capable of radiating and capturing electromagnetic energy.
Transmission Lines	Couples energy from a transmitter to an antenna or from antenna to a receiver.
Waveguide	A special type of transmission line that consists of a conducting metallic tube through which high-frequency electromagnetic energy is propagated.
Radio Waves	Electrical energy that has escaped into free space in the form of transverse electromagnetic waves
Wavefront	The plane parallel to the mutually perpendicular lines of the electric and magnetic fields.
Radiation Efficiency	The ratio of radiated to reflected energy.
Quarter Wave Antenna	Antenna wherein two conductors are spread out in a straight line to a total length of one quarter wavelength.
Vertical Monopole or Marconi	Another name for quarter wave antenna.
Hertz Antenna	A half-wave dipole.
Diplexer	A special coupling device that can be used to direct the transmit and receive signals and provide the necessary isolation.

Radiation Pattern	A polar diagram or graph representing field strengths or power densities at various angular positions relative to an antenna.
Absolute Radiation Pattern	Radiation pattern plotted in terms of electric field strength or power density.
Relative Radiation	Radiation pattern plots field strength or power density with respect to the value at a reference
Major Lobes	The primary beam of an antenna.
Front Lobe	The major lobes that propagates and receive the most energy.
Side lobes	Lobes adjacent to the front lobe.
Minor Lobes	The secondary beam of an antenna.
Back Lobe	Lobes in a direction exactly opposite the front lobe
Front to Back Ratio	The ratio of the front lobe power to the back lobe power.
Front to Side Ratio	The ratio of the front lobe to a side lobe.
Line of Shoot or Point of Shoot	The line bisecting the major lobe, or pointing from the center of the antenna in the direction of maximum radiation.
Omni-directional Antenna	Antenna that radiates energy equally in all directions.
Isotropic Radiator	Radiates power at a constant rate uniformly in all directions.
Maximum Radiation	The direction in which an antenna is always pointing.
EIRP	It is defined as an equivalent transmits power. It stands for Effective Isotropic Radiated Power.
Effective Radiated Power (ERP) or (EIRP)	The equivalent power that an isotropic antenna would have to radiate to achieve the same power density in the chosen direction at a given point as another antenna.
Captured Power Density	The power density in space and the actual power that a receive antenna produces at its output terminals.
Capture Area	It describe the reception properties of an antenna.
Effective Area	Another name for capture area.
Directly Proportional	The relationship of captured power to the received power density and the effective capture area of the received antenna.
Polarization	It refers to the orientation of the electric field radiated from the antenna.
Antenna Bandwidth	The angular separation between the two half-power(-3dB) points on the major lobe of an antenna's plane radiation pattern.

Antenna Bandwidth	The frequency range over which antenna operation is satisfactory.
Feedpoint	Another name for antenna input terminal
Antenna Input Impedance	The feedpoint presents an ac load to the transmission line.
Elementary Doublet	<p>The simplest type of antenna. <u>Another names for elementary doublet</u></p> <ul style="list-style-type: none"> • Short Dipole, • Elementary Dipole • Hertzian Dipole
Electrically Short	Any dipole that is less than one-tenth wavelength.
Heinrich Hertz	Hertz antenna is name after him and he was the first to demonstrate the existence of electromagnetic waves.
Marconi Antenna	A single pole antenna one quarter wavelength long, mounted vertically with the lower end either connected directly to ground or grounded through the antenna coupling network.
Must be close to the Ground	Main disadvantage of Marconi Antenna.
Loading	A technique use to increase the electrical length of an antenna.
Loading Coil	A coil added in series with a dipole antenna which effectively increases antenna's electrical length.
5 Ohms	A loading coil approximately increases the radiation resistance of the antenna.
Antenna Element	<p>An individual radiator, such as a half or quarter wave dipole <u>Two types of antenna elements</u></p> <ul style="list-style-type: none"> • Driven • Parasitic <p><u>Two Elements of a single antenna</u></p> <ul style="list-style-type: none"> • Two Wire • Folded Dipole
Array	Its purpose is to increase the directivity and concentrate the radiated power within a smaller geographic area.
Driven	Elements that are directly connected to the transmission line and receive power from the source.
Parasitic	Elements are not connected to the transmission line; they receive energy only through mutual induction with a driven element.
Director	A parasitic element that is shorter that its associated driven element.
Driven	Radiation pattern depends on the relative phase of feeds.
Broadside Arrays	The simplest type of antenna arrays.

Yagi Uda	A widely used antenna commonly uses a folded dipole as the driven element and named after two Japanese scientists.
7 dB and 9 dB	Typical directivity of a yagi-uda antenna.
Turnstile Antenna	Formed by placing two dipoles at right angles to each other.
Log Periodic	A class of frequency-independent antennas.
Helical Antenna	<p>A broadband VHF or UHF antenna that is ideally suited for applications for which radiating circular rather than horizontal or vertical polarized electromagnetic waves are required.</p> <p><u>Modes of propagation:</u></p> <ul style="list-style-type: none"> • Normal • Axial •
Microwave Antenna	<p>Antennas having half power beamwidths on the order of 1° or less.</p> <p><u>Three important characteristics:</u></p> <ul style="list-style-type: none"> • Front-to Back Ratio, • Side-toSide Coupling • Back-to-Back Coupling
Parabolic Reflector Antenna	<p>Antenna that provides extremely high gain and directivity and are very popular for microwave and satellite communications link.</p> <p><u>Two main part</u></p> <ul style="list-style-type: none"> • Parabolic Reflector • Feed Mechanism
Capture Area	The effective area in a receiving parabolic antenna and is always less than the actual mouth area.

CHAPTER 16: TELEPHONE INSTRUMENTS AND SIGNALS

TERMS	DEFINITIONS
Communications	Process of conveying information from one place to another
Telecommunications	Is a long-distance communications
Telephone	One of the most remarkable devices ever invented.
Public Telephone Network	Anyone who uses a telephone or a data modem on a telephone circuit is part of a global communications network .

Telco	The PTN is comprised of several very large corporations and hundreds of smaller independent companies jointly.
Alexander Graham Bell and Thomas A. Watson	The telephone system as we know it today began as an unlikely collaboration of two men with widely disparate personalities:
Plain Old Telephone Service	The simplest and most straightforward form of telephone service.
Subscriber Loop or Local Loop	Most fundamental component of a telephone circuit.
Local Loop	An unshielded twisted-pair transmission line consisting of two insulated conductors twisted together
Telephone	Comes from the Greek word "tele" meaning from afar and phone, meaning sound, voice, or voiced sound.
Butterstamp Telephone	The first telephone set that combined a transmitter and receiver into a single handheld unit was introduced in 1878
Sidetone or Talkback	Helps prevent the speaker from talking too loudly.
Local Loop	The pair of wires connecting.
RJ or Registered Jacks	A series of telephone connection interfaces that are registered with the U.S. Federal Communications Commission.
RJ-11	The most common telephone jack in use today and can have up to six conductors.
Telephone Set	An apparatus that creates an exact likeness of sound waves with an electric current.
Ringer Circuit	Is originally an electromagnetic bell, placed directly across the tip of the ring of the local loop.
Alert the destination party of incoming calls	Purpose of a Ringer.
On/Off Hook Circuit	Sometimes called a Switch Hook.
Equalizers	Helps solve an important transmission problem in telephone set design.
Microphone	Is the transmitter of the telephone.
Microphone	Converts acoustical signals in the form of sound pressure waves from the caller to electrical signals that are transmitted into the telephone network.
Dialing Circuit	Enables the subscriber to output signals representing digits.
Alerting, Supervising, Controlling, and Addressing	Signaling messages can be subdivided further into one or four categories:
Alerting Signals	Indicate a request for service.
Supervising Signals	Provide call status information.
Controlling Signals	Provide information in the form of announcements.
Addressing Signals	Provide the routing information..
DTMF	Is strictly for signaling between a subscriber's location and the nearest telephone office or message switching center.
Multifrequency Tones	Are used to transfer digits and control signals between switching machines.
MF Tones	Are combinations of two frequencies that fall within the normal speech bandwidth so they can be propagated over the same circuits as voice.
Congestion Tone or No-Circuit-Available	Occurs whenever the system is overloaded and more calls are being placed than can be completed.
Blocking	Is sent from a central office to a subscriber whenever there is an incoming call.

Ringing signal	It is when the produced cross-products are undesired when two or more frequencies mix in a nonlinear device.
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CHAPTER 17: TELEPHONE CIRCUIT

TERMS	DEFINITIONS
Telephone Circuit	It comprised of two or more facilities, interconnected in tandem, to provide a transmission path between a source and a destination.
Message	The information transferred in a telephone circuit
Message Circuit	The circuit used in transferring information in a telephone circuit.
4 kHz	The network bandwidth for a standard voice-band message channel.
Guard Bands	Unused frequency bands located between information signals.
300 Hz to 3000 Hz	Effective channel bandwidth for a voice-band message signal.
Local Subscriber Loop	The only facility required by all voice-band circuits, as it is the means by which subscriber locations are connected to the local telephone company
Two components found on local loops: Loading Coils Bridge Taps	The primary cause of attenuation and phase distortion on a telephone circuit.
Feeder Cable (F1)	The largest cable used in a local loop, usually 3600 pair of copper wire

	placed underground or in conduit.
Serving Area Interface	A cross-connect point used to distribute the larger feeder cable into smaller distribution cables.
Distribution Cable	A smaller version of a feeder cable containing less wire pairs.
Subscriber or Standard Network Interface (SNI)	A device that serves as the demarcation point between local telephone company responsibility and subscriber responsibility for telephone service.
Drop Wire	The final length of cable pair that terminates at the SNI.
Aerial	That portion of the local loop that is strung between poles.
Distribution Cable and Drop Wire Cross Connect Point	The location where individual cable pairs within a distribution cable are separated and extended to the subscriber's location on a drop wire.
Loading	Adding inductors periodically in series with the wire.
Loading Coil	The inductor in loading technique.
Bridge Tap	An irregularity frequently found in cables serving subscriber location.
Bridging Loss	A loss that allows signals to split and propagation down more than one wire introduced by bridge taps.
C-Message Weighting	Weighting network introduced by AT & T to accomplish equal magnitude of noise signals.
1000 Hz	The most annoying frequency to human (i.e. the best frequency response).

Decibel (dB)	The basic yardstick used for making power measurements in communications.
Transmission Level Point (TLP)	The optimum level of a test tone on a channel at some point in a communications system. It is used for voice circuits.
Transmission Level (TL)	The ratio in dB of the power of a signal at that point to the power the same signal would be at 0 dBm transmission level point.
0 dBm	The reference for TLP.
Data Level Point (DLP)	A parameter equivalent to TLP except it is used as a reference for data transmission.
dBmO	dBm reference to a zero transmission level point.
reference noise (rn)	dB reference value for noise reading.
dBm	dB level of noise with respect to reference noise (- 90 dBm).
dBnc	Similar to dBm except it is the dB value of noise with respect to reference noise using C-message weighting
dBm 3 kHz Flat	Noise readings taken with a filter that has a flat frequency response from 30 Hz to 3 kHz
dBncO	The amount of noise in dBnc corrected to a 0 TLP
Interface Parameters	Transmission parameters which include terminal impedance, in band and out of band signal power, test signal power and ground isolation.
Facility Parameters	Transmission parameters which includes noise measurements, frequency distortion, phase distortion, amplitude distortion and non

	linear distortion.
Attenuation Distortion	<p>The difference in circuit gain experienced at a particular frequency with respect to the circuit gain of a reference frequency.</p> <p><u>Another names attenuation distortion:</u></p> <ul style="list-style-type: none"> • Frequency Response, • Differential Gain • 1004-Hz Deviation
Envelope Delay Distortion	An indirect method of evaluating the phase delay characteristics of a circuit.
Basic Voice-Band Channel	It satisfies the minimum line conditioning requirements
Basic 3002 Channel	Another name for basic voice-band.
C-type Conditioning	<p>Specifies the maximum limits for attenuation distortion and envelope delay distortion.</p> <p>Classifications of C-type:</p> <ul style="list-style-type: none"> • C1 • C2 • C3 • C4 • C5
C1 and C2	Classification of C-type conditioning pertains to two point and multi point circuits.
C3	C-type conditioning used for access lines and trunk circuits associated with private switched networks.
C4	C-type conditioning pertains to two point and multi point circuits with a maximum of four stations
C5	C-type conditioning pertains to two point circuits only

Private Branch Exchange (PBX)	A relatively low-capacity switching machine where the subscribers are generally limited to stations within the same building or building complex.
Attenuation Distortion	The frequency response of a transmission medium referenced to 1004 Hz test tone.
Linear Phase vs. Frequency	A requirement for error free data transmission.
Delay Distortion	The difference in phase shifts with respect to frequency that signals experience as they propagate through a transmission medium.
Propagation Time	The time delay encountered by a signal as it propagates from source to a destination.
Phase Delay	The delay measured in angular units.
Absolute Phase Delay	The actual time required for a particular frequency to propagate from a source to a destination through a communications channel.
Envelope Delay	The time required to propagate a change in an AM envelope through a transmission medium.
Envelope Delay Distortion	The phase difference at the different carrier frequencies.
D-Type Line Conditioning	It sets the minimum requirements for signal to noise ratio and nonlinear distortion.
9600 bps	The data transmission rate when D type conditioning is mandatory.
1004 Hz	Telephone industry standard test tone frequency

C-message Noise Measurement	Measurement that determine the average weighted rms noise power.
Loaded	A communications term that indicates the presence of a signal power comparable to the power of an actual message transmission.
Impulse Noise	Characterized by high amplitude peaks of short duration having an approximate flat frequency spectrum
Gain Hit	A sudden, random change in the gain of a circuit resulting in a temporary change in the signal level.
Dropout	A decrease in circuit gain of more than 12 dB lasting longer than 4 ms.
Phase Hits (Slips)	A sudden, random change in the phase of a signal.
Phase Jitter	A form of incidental phase modulation - a continuous, uncontrolled variation in the zero crossings of a signal.
Single Frequency Interference	The presence of one or more continuous, unwanted tones within a message channel.
Spurious Tones	Unwanted tones within a message channel.
Frequency Shift	The frequency of the signal changes during transmission.
Phase Intercept Distortion	It occurs in coherent SSBSC systems when the received carrier is not reinserted with the exact phase relationship to the received signal as the transmit carrier possessed.
Phase Intercept Distortion	It occurs in coherent SSBSC systems when the received carrier is not reinserted with the exact phase relationship to the received signal as the transmit carrier possessed.

Hybrid Set	A four wire circuit an interface.
Terminating Set	Another name for hybrid set.
Crosstalk	Any disturbance created in a communications channel by signals in other communications channels.
Intelligible crosstalk	Annoying and objectionable because the listener senses a real or fancied loss of privacy
Unintelligible crosstalk	It does not violate privacy, although it can still be annoying.
Nonlinear Crosstalk	A direct result of nonlinear amplification in analog communications system.
Coupling Crosstalk	Electromagnetic coupling between two or more physically isolated transmission media.
Transmittance Crosstalk	Interference caused by inadequate control of the transfer characteristics or transmittance of networks.

CHAPTER 18: PUBLIC TELEPHONE NETWORK

TERMS	DEFINITIONS
Public Telephone Network (PTN)	It uses the largest computer network in the world to interconnect millions of subscribers in such a way that the myriad of companies function as a single entity.
Switching	Identifies and connects the subscribers to a suitable transmission path.

Signaling	Supply and interpret control and supervisory signals needed to perform the operation.
Service Providers	The public telephone companies.
Common Usage Equipment	Equipment and facilities that are available to all public subscribers to the network.
Dial-Up Network	Another name for Public Switched Telephone Network (PSTN).
Data Transmission	The transmittal of digital information between two pieces of digital equipment.
Instrument	Any device used to originate and terminate calls and to transmit and receive signals into and out of the telephone network.
Station Equipment	The instrument is often referred.
Station	The location of the equipment.
Subscriber	The operator or user of the instrument.
Local Loop	The dedicated cable facility used to connect an instrument at a subscriber's station to the closest telephone office.
Trunk Circuits	Similar to local loop except trunk circuits are used to interconnect two telephone offices.
Exchange	A central location where subscribers are interconnected, either temporarily or on permanent basis.
Switching Machines	Programmable matrices that provide temporary signal paths between two subscribers.

Local Exchanges	Exchanges connected directly to local loops.
January 28, 1878	The first commercial telephone switchboard began operation New Haven, Connecticut.
Switchboards	The first local telephone exchanges
Automated Switching System	A system of sensors, switches, and other electrical and electronic devices that allows subscribers to give instructions directly to the switch without having to go through an operator.
Mechanical Dialer	Allowed subscribers to manually dial the telephone number of the party they wished to call.
Strowger Switch	Commonly called for stepper or step-by-step (SXS).
Circuit	Simply the path over which voice, data, or video signals propagate.
Circuit Switch	A programmable matrix that allows circuits to be connected tom one another.
Intraoffice Call	Telephone call completed within a single local exchange.
Interoffice calls	Telephone calls placed between two stations that are connected to different local exchanges.
Interswitch Calls	Another name for interoffice calls.
Trunks or Interoffice Trunk	Telephone switching machines in local exchanges are connected to other local exchange office.
Tandem Office	It is used to interconnect local offices that do not have interoffice trunks directly between them. An exchange without any local loops connected to it.

Tandem	Switches that interconnect local offices only.
Tandem Trunk or Intermediate Trunk	Trunk circuits that terminates in tandem switches.
Toll Office	Interstate long distance telephone calls require a special telephone office.
North American Telephone Numbering Plan (NANP)	Provides telephone numbering system for the United States, Mexico and Canada.
Concentrator	It allows many subscribers to share a limited number of lines to a central office switch.
Route	A path between two subscribers and is comprised of one or more switches, two local loops; and possibly one or more trunk circuits.
Blocking	A call that calls cannot be completed because the necessary trunk circuits or switching paths are not available, the calling party receives an equipment busy signal.
Class 5 End Switching Office	A local exchange where subscriber loops terminated and received dial tone.
Class 4P Switching Office	Class 4 office having only outward and inward calling service.
Class 4C	Class 4 office provided human operators for both outward and inward calling service.
Class 3 Primary Center	Switching office that provides service to small groups of class 4 offices within a small area of a state.

Class 2 Sectional	Sectional centers that could provide service to geographical regions varying in size from part of a state to all of several states.
Class 1 Regional Center	Regional centers were the highest ranking office in the DDD network in terms of the size of the geographical area served and the trunking options available.
Intermediate Links	Toll trunks in tandem, excluding the two terminating links at the ends of the connection.
Common Channel Signaling System No. 7 (SS7 or C7)	A global standard for telecommunications defined by the ITU.
Signaling	Refers to the exchange of information between call components required to provide and maintain service.
SS7	An architecture for performing out of band signaling in support of common telephone system functions.
Point of Presence (POP)	Long distance access is now accomplished through an access point.
POP	A telecommunications term that describes the legal boundaries for the responsibility of maintaining equipment and transmission lines.
Signaling Points	Provide access to the SS7 network, access to databases used by switches inside and outside the network.
Point Codes	Codes that are carried in signaling messages exchanged between signaling points to identify the source and destination of each message.
Service Switching	

Points	Local telephone switches equipped with SS7 compatible software and terminating signal links.
Signal Transfer Points	The packet switches of the SS7 network.
Service Control Points	It serves as an interface to telephone company databases.
Signal Control Points	Another name for service control points.
Primitive	Provides access from one level of the protocol to another

CHAPTER 19: CELLULAR TELEPHONE CONCEPTS

TERMS	DEFINITIONS
Mobile Telephone Manual System (MTSs)	The term for mobile telephone services which began in 1940s and are sometimes called Manual telephone systems.
35 MHz-45MHz	The frequency used by MTSs.
Push-to-Talk (PTT)	Switch that was used by MTS to activate the transceiver.
Improved Mobile Telephone System (IMTS)	It was introduced in 1964 which used several carrier frequencies and could, therefore, handle several simultaneous mobile conversations at the same time.
Mobile	The term suggested any radio transmitter, receiver, or transceiver that could be moved while operation.

Portable	The term that described a relatively small radio unit that was handled, battery powered, and easily carried by a person moving at walking speed.
Cellular Telephone	It is similar to two-way mobile radio in that most communications occurs between base stations and mobile units.
Two-Way Radio	It operates on half duplex and use PTT transceivers. <u>examples of two-way radio:</u> <ul style="list-style-type: none"> • Citizens Band (CB) • Public land mobile radio
Mobile Telephone	A one to one system that permits two-way simultaneous transmissions and operates the same way as the standard wire line telephone service.
E.K. Jett	Hinted of a cellular telephone scheme that he referred to as simply a small-zone radio telephone system in the July 28, 1945.
AT&T and Southwestern Bell	On June 17, 1946, they introduced the first American commercial mobile radio-telephone service to private customers.
Highway Service.	A radio telephone service introduced by AT&T in 1947.
Don Adams	Unveiled the most famous mobile telephone to date: the fully mobile shoe phone in 1966 in a television show called Get Smart
1975	The year when FCC granted AT&T the first license to operate a developmental cellular telephone service in Chicago.
Iridium	A satellite-based wireless personal communications satellite (PCSS)
Cellular Radio	Another term for cellular telephone.
Coverage zone	A large geographic market area.

Frequency Reuse	It is employed to increase the capacity of a mobile telephone channel.
Honeycomb	The shape that was used because it provides the most effective transmission by approximating a circular pattern while eliminating the gaps present between adjacent circles.
Macrocells	Large cells that typically has 1 mile and 15 miles radius with base station transmit power 1W and 6 W.
Microcells	The smallest cells that typically has radius of 1500 feet or less with base station transmit powers between 0.1 W and 1 W.
Frequency Reuse	The process, in which the same set of frequencies can be allocated to more than one cell, provided the cells are separated by sufficient distance.
cluster	A geographic cellular radio coverage area containing three groups of cells.
Cluster size	Typically equal to 3, 7, or 12.
First Tier	The process of finding the tier with the nearest co-channel cells
Co-channel cells	Two cells using the same set of frequencies.
Co-channel Interference	<p>The interference between the co-channels cells.</p> <p><u>Adding radio channels to a system:</u></p> <ul style="list-style-type: none"> • Decreasing the transmit power per cell • making cells smaller • filling vacated coverage areas with new cells

Adjacent Channel	Channel next to one another in the frequency domain.
Adjacent-Channel Interference	It results from imperfect filters in receivers that allow nearby frequencies to enter the receiver.
Near-Far Effect	Most prevalent when a mobile unit is receiving a weak signal from the base station.
Cell Splitting	The area of a cell, or independent component coverage areas of cellular system is further subdivided thus creating more areas.
Maximum Traffic Load	Occurs when number of the number of subscriber wishing to place a call at any given time equals the number of channels in the cell.
Blocking	A condition occurs when a new call is initiated in an area where all the channels are in use.
Sectors	Smaller areas when a single omnidirectional antenna is replaced by several directional antennas, each radiating within smaller area.
Sectoring	Using directional antennas.
Space Diversity	Placing two receive antennas one above the other.
Dualization	A means of avoiding full-cell splitting where the entire area would otherwise need to be segmented into smaller cells.
Segmentation	A means of avoiding co-channel interference, although it lowers the capacity of a cell by enabling reuse inside the reuse distance which is normally prohibited.
Base Stations	The locations of radio-frequency transceivers. It serves are central control for all users within that cell.

Cell-Site Controller	It handles all cell-site control and switching functions.
Roaming	Occurs when a mobile unit moves from one cell to another company's service.
Mobile Telephone Switching Office (MTSO)	<p>It controls channel assignment, call processing, call setup and call termination.</p> <p><u>Different Names:</u></p> <ul style="list-style-type: none"> • Electric Mobile Exchange (EMX)- Bell Lab. • AEX- Ericsson • NEAX-NEC • Switching Mobile Center (SMC) • Master Mobile Center (MMC)-Novatel • Mobile Switching Center- PCS networks
Handoff (Handover)	<p>The transfer of a mobile unit from one base station's control to another base station's control.</p> <p><u>Four stages:</u></p> <ul style="list-style-type: none"> • Initiation • Resource reservation • execution • completion
Hard Handoff	A connection that is momentarily broken during the cell-to-cell transfer. It is a break before-make process.
Soft Handoff	A flawless hand off with no perceivable interruption of service.
Handoff Decision	It is used by computers that are based on variations in signal strength and signal quality.
Initiation	Either the mobile unit or the network determines the need for a handoff and initiates the necessary network procedures.
Resources Reservation	Appropriate network procedures reserve the resources needed to

	support the handoff.
Execution	The actual transfer of control from one base station to another base station takes place.
Completion	Execution Unnecessary network resources are relinquished and made available to other mobile units.
Interoperator Roaming	Roaming from one company's calling area into another company's calling area.
EIA/TIA	Stands for Electronics Industries Association/Telecommunications Industry Association, developed the IS-41 Protocol.
IS-41	It aligns with a sub protocol of the SS7 protocol stack that facilitates communications among database other network entities.
CITA	Stands for Cellular Telecommunication Industry Association.
Autonomous Registration	<p>The process where a mobile unit notifies a serving MTSO of its presence and location through a base station controller.</p> <p><u>Components of Cellular Telephone System:</u></p> <ul style="list-style-type: none"> • Electronic switching center • a Cell-site controller • radio transceiver • system interconnections • mobile telephone units • common communications protocol
Electronic Switching Center	A digital telephone exchange located in the MTSO that is the heart of a cellular telephone system.
X.25	A datalink protocol at a transmission rate of 9.6 kbps.
Base Station	Another name for cell-site controller.

Controller	
Cell-site Controller	It manages each of the radio channels at each site supervises calls, turns the radio transmitter and receiver on and off, injects data onto the control and voice channels, and performs diagnostic tests in the cell-site equipment.
BTS	Stands for Base transceiver station.
Radio Transceiver	A part of base station subsystem that can be either narrowband FM analog system or either PSK or QAM for digital systems with effective audio frequency.
Receiver Diversity	The radio receiver that detects the strongest signal.
Communications Protocol	<p>It governs the way telephone calls are established and disconnected.</p> <p><u>Examples of Protocol:</u></p> <ul style="list-style-type: none"> • IS-54 • IS-136.2 • IS-95
User Channel	The actual voice channel where mobile users communicate directly with either mobile or wireline subscribers through a base station.
Control Channel	<p>It is used for transferring control and diagnostic information between mobile users and a central cellular telephone switch through a base station.</p> <p><u>Transmit on base station:</u></p> <ul style="list-style-type: none"> • forward control channel • forward voice channel <p><u>Receive on base stations:</u></p> <ul style="list-style-type: none"> • reverse control channel • reverse voice channel

	<p><u>types of calls:</u></p> <ul style="list-style-type: none"> • Mobile to wireline • mobile to mobile • wireline to mobile
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CHAPTER 20: CELLULAR TELEPHONE SYSTEM

TERMS	DEFINITIONS
CTS	Stands for Standard Cellular Telephone Service
PCS	An acronym for Personal Communications System.
PCSS	Stands for Personal Communications Satellite System.
AMPS	An acronym for Advanced Mobile Telephone System.
Bell Telephone Laboratories	Proposed the cellular telephone concept in 1971.
AMPS	A standard cellular telephone service (CTS) initially placed into operation on Oct. 13, 1983.
Narrowband Frequency Modulation (NBFM)	It was used by AMPS cellular telephones with usable audio-frequency band from 300 Hz to 3 KHz and a maximum frequency deviation of ± 12 KHz for 100% modulation.
Carson's Rule	Correspond to an approximate bandwidth of 30 KHz.
Full Duplex (FDX) or Duplexing	A transmission with simultaneous transmission in both direction.
Frequency-division Duplexing	It is used in AMPS and occurs when two distinct frequency bands are provided to each user.
Duplexer	A special device used in each mobile unit to allow simultaneous transmission and reception on duplex channels.
Forward Links	Transmissions from base station to mobile units.
Reverse Links	Transmissions from mobile units to base stations.
Down Links	Another name for forward links.

Uplink	Another term for reverse link.
Expanded Spectrum	Additional frequencies of 10 MHz to the original 40 MHz band which increased the number of simplex channels by 166 for a total of 832 (416 Full duplex)
Cellular Geographic Serving Areas (CGSA)	Specified frequencies in a small geographic area.
Standard Metropolitan Statistical Area	Defines geographic areas used by marketing agencies.
Frequency Division Multiple Access	A technique used by standard telephone subscriber to access the AMPS system.
Mobile Identification Number (MIN)	A 34 bit binary code which in the U.S. represents the standard 10-digit telephone number.
Electronic Serial Number (ESN)	A 34 bit binary code permanently assigned to each mobile unit.
VIN	Stands for Vehicle Identification Number.
NIC	An acronym for Network Interface Card.
Station Class Mark (SCM)	A four bit code which indicates whether the terminal has access to all 832 AMPS channel or only 666.
System Identifier (SID)	A 15 bit binary code used by FCC to an operating company when it issues it a license to provide AMPS
Supervisory Audio Tone (SAT)	It is one of the three analog frequencies (5970 Hz, 6000 Hz, or 6030 Hz) that help mobile system distinguish one base station from a neighboring base station.
Digital Color Code (DCC)	One of four binary codes, also helps mobile system distinguish one base station from a neighboring base station.
Control Channels	One set of channels dedicated for exchanging control information between mobile units and base stations
User Channel	Also termed as Voice channel, used for propagating actual voice conversations or subscriber data.
Setup or Paging Channel	Another name of control channels.
Locked	Sometimes called as Camped.
Dotting Scheme	Sometimes called as Camped.
Synchronization Word	A unique sequence of 1s and 0s that enables the receiver to instantly acquire synchronization.

Mobile Station Control Messages	It controls or command mobile units to do a particular task when the mobile unit has not been assigned a voice channel.
Busy-idle Bits	It is used to indicate the current status of the reverse control channel.
Overhead Message	<p>It contains the following:</p> <ul style="list-style-type: none"> • System parameter overhead messages • global action overhead messages • control filter messages <p><u>Typical mobile-unit control messages:</u></p> <ul style="list-style-type: none"> • Initial voice channel designation messages • directed retry messages • alert messages • change power messages
Control Data	<p>Transmitted at a 10-kbps rate.</p> <p><u>Control data includes:</u></p> <ul style="list-style-type: none"> • page responses • access request • registration requests
Blank	Transmission of voice.
Burst	Data transmission.
Intelligent Network	<p>The entity of SS7 interoffice protocol that distinguishes the physical components of the switching network.</p> <p><u>Switching Network:</u></p> <ul style="list-style-type: none"> • Signal Service Point • Signal Control Point • Signal Transfer Point
Personal Communications System (PCS)	<p>A family of mobile or portable radio communications services which provides services to the individuals and business and is integrated with a variety of competing networks.</p> <p><u>Differences in PCS and cellular telephonesystem:</u></p> <ul style="list-style-type: none"> • Smaller Size • all digital • additional features •
PCN	Acronym for Personal Communications Network.
Personal Telephone Number	It is assigned to everyone which is stored the on the SS7 network.
Artificial Intelligence Network (AIN)	It determines where and how the call should be directed.
Home Location Register (HLR)	A database that stores information about the user, including home subscription information and what supplementary services the user is subscribed to.

Equipment Identification Registry (EIR)	A database that stores information pertaining to the identification and type of equipment that exists in the mobile unit.
Available Mode	It allows all calls to pass through the network to the subscriber except for a minimal number of telephone numbers that can be blocked.
Private Mode	All calls except those specified by the subscriber are automatically forwarded to a forwarding destination without ringing the subscriber's handset.
Unavailable Mode	No calls are allowed to pass through to the subscriber.
PCS 1900	PCS operating in the 1900 MHz range.
Interference (MRI)	Interference avoidance scheme which uses voice companding to provide synthetic channel quieting.
N-AMPS	A narrowband AMPS system that increased the capacity of the AMPS system in the cellular market.
United States Digital Cellular	It is developed with the intent of supporting a higher user density within a fixed bandwidth frequency spectrum.
Digital cellular	Cellular telephone systems that use digital modulation.
Time-division Multiple Accessing(TDMA)	Allows one mobile unit to use a channel at the same time by further dividing transmissions within each cellular channel.
Visitor Location Register(VLR)	A database that stores information about subscriber in a particular MTSO serving area, such as whether the unit is on or off
Time-Sharing Channels	Technique used that allows more mobile-unit subscribers to use a system at virtually same time within a given geographical area.
EIA/TIA	It stands for Electronics Industries Association and Telecommunications Industry Association.
Dual Mode	It specifies that a mobile station complying with the IS-54 standard must be capable of operating in either the analog AMPS or the digital (USDC) mode for voice transmission.
IS-136.2	It is often called North American Time Division Multiple Accessing.
IS-54 Rev.C	It was introduced to provide PSK rather than FSK on dedicated USDC control channels to increase the control data rates and provide additional specialized services such as paging and short messaging between private mobile user groups.
Short Message Service	Allows for brief paging-type messages and Short e-mail messages that can be read on the mobile phone's display and entered using the keypad.
IS-136	It was developed to provide a host of new features and services, positioning itself as competitive within the newer PCS systems.

Random Access Channel(RACH)	It is used by mobile units to request access to the cellular telephone system. It is a unidirectional channel specified for transmissions from mobile-base units only.
SMS point-to-point Paging and access response Channel (SPACH)	It is used to transmit information from base stations to specific mobile stations.
Paging Channel (PCH)	It is dedicated to delivering pages and orders. <u>It transmit :</u> <ul style="list-style-type: none"> • paging messages • message-waiting messages • user alerting messages • call history count updates • shared secret data updates
Access Response Channel(ARCH)	A logical subchannel of SPACH used to carry assignments to another resource or other responses to the mobile station's access attempt.
SMS Channel (SMSCH)	It is used to deliver short point-to-point messages to a specific mobile station.
Channel (BCCH)	It refers to: F-BCCH, E-BCCH and S-BCCH logical sub channels.
Fast Broadcasts Control channel (F-BBCH)	Broadcasts digital control channel structure parameters.
Extended Broadcasts Control Channel (E-BBCH)	Carries less critical broadcast information than F-BCCH intended for mobile units.
SMS Broadcasts Control channel (F-BBCH)	Individual mobile units. A logical channels used for sending short messages.
DSI	Stands for Digital speech interpolation.
Digital Traffic Channel (DTC)	Carries digital voice information and consists of RDTC and FDTC
Coded Digital Verification Color Code	It consists of an eight bit digital voice color code number between 1 and 255 appended with four
MAHO	Mobile-assisted handoff
Fast Associated Control Channel (FACCH)	A blank-and burst type of transmission that replaces digitized speech information with control and supervision messages within a subscriber's time slot.
Vector sum exciter linear predictive (VSLP)	A special speech coder.

Digital Signal Processor(DSP)	A special microprocessor that is implemented on the telephone handset.
Shortened Burst	They are transmitted when a mobile unit begins operating in a larger diameter cell.
FDMA	An access method used with standard analog AMPS which use frequency channelization approach to frequency spectrum management.
Code Division Multiple Accessing (CDMA)	It allows users to differentiate from one another by a unique code rather than a frequency or time assignment.
QCELP	Stands for Qualcomm 9600bps Code-Excited Linear Predictive coder.
Frequency Hopping	The concept is to break the message into fixed sized blocks of data with each block transmitted in sequence except on a different carrier.
Direct-Sequence	high bit pseudorandom code is added to a low-bit rate information signal to generate a high bit rate pseudorandom signal closely resembling noise that contains both the original data signal and the pseudo random code must be known.
Groupe Special Mobile (GSM)	<p>It is a study group which is sometimes referred to as Pan-European cellular system. This is now known as the Global System for Mobile Communications.</p> <p><u>Classification of GSM telephone services:</u></p> <ul style="list-style-type: none"> • Bearer Services • teleservices • supplementary services <p><u>Three primary subsystem of GSM:</u></p> <ul style="list-style-type: none"> • Base Station Subsystem • Network Switching Subsystem • Operational Support Subsystem
Integrated Services Digital Network (ISDN)	All-digital data Network.
Base Station Subsystem (BSS)	Sometimes known as radio subsystem, provides and manages radio frequency transmission paths between mobile units and the mobile switching center (MSC)
Network Switching Subsystem (NSS)	It manages switching functions for the system and allows MSCs to communicate with other telephone networks.
Absolute Radio-Frequency Channel Numbers (ARFCN)	The available forward and reverse frequency bands are subdivided into 200 KHz wide voice channels.
Mobile Satellite Systems	It provides the vehicle for a new generation of wireless telephone services called Personal Communications Satellite System (PCSS)

(MSS)	
Personal Communications Satellite System (PCSS)	<p>It uses low earth-orbit (LEO) and medium earth orbit and MEO that communicates directly with small, low-powered mobile telephone units.</p> <p><u>key providers in PCSS market:</u></p> <ul style="list-style-type: none"> • American Mobile Satellite Communications (AMSC) • Celsat • Comsat • Constellation Communications (ARIES) • Ellipsat (Ellipso) • INMARSAT • LEOSAT • Loral/qualcomm (global star) • TMI communications • TWR (Odysse) • Iridium LLC
Iridium LC	An international consortium owned by a host of prominent companies, agencies and governments.
Iridium Project	The largest commercial venture undertaken in the history of the world.
Iridium	A satellite based wireless personal communications network designed to permit a wide range of mobile telephone services, including voice, data, networking, facsimile and paging.
October 14, 1994	FCC issued a report and order Docket # 92-166 defining L band frequency sharing for subscriber units in the 1616 MHz to 1626.5 MHz band.
1.616 GHz to 1.6265 GHz	L-band subscriber-to-satellite voice links.
19.4 GHz to 19.6 GHz	Ka-band gateway downlinks.
29.1 GHz to 29.3 GHz	Ka-band gateway uplinks

CHAPTER 21: INTRODUCTION TO DATA COMMUNICATIONS AND NETWORKING

Data	Information that is stored in digital form. Information that has been processed organized and stored.
Information	Knowledge or intelligence.
Data Communications	The transmission, reception, and processing of digital information.
Data Communications	It is to transfer digital information from one place to another.

Circuit	
Network	A set of devices interconnected by media links.
Data Communications Networks	Systems of interrelated computers and computer equipment and can be as simple as a personal computer connected together through the PTN
ATM	Automatic teller machine
1753	One of the earliest means of communicating electrically coded information occurred
Carl Friedrich Gauss	In 1833, he developed an unusual system based on a five-by-five matrix representing 25 letters. The idea was to send message over a single wire.
Telegraph	The first successful data communications that was invented in 1832. Dots and Dashes
Samuel F.B. Morse	He invented the first practical data communications code which is called Morse Code.
1. Sir Charles Wheatstone 2. Sir William Cooke	Allegedly invented the first telegraph in England.
Emile Baudot	In 1874, he invented the telegraph multiplexer which Emile allowed up to six different telegraph machines to be transmitted simultaneously over a single wire.
Telephone	It was invented in 1875 by Alexander Graham Bell
Guglielmo Marconi	He succeeded in sending radio telegraph messages.
Telegraph	The only means of sending information across large spans of water until 1920.
Konrad Zuis	A German engineer, demonstrated a computing machine sometime in the late 1930s.
J. Presper Eckert John Mauchley	Developed the ENIAC computer on Feb. 14, 1946
Batch Processing	A technique that process one job at a time.
UNIVAC Computer	Built in 1951 by Remington Rand Corp., was the First mass-produced electronic computer.
Internet	A public data communications network used by millions of people all over the world to exchange business and personal information.
Intranet	Private data communications networks used by many companies to exchange information among employees and resources.

Data Communications Network	Any system of computers, computer terminals or computer peripheral equipment used to transmit and receive information between two or more locations.
Network Architecture	A set of equipment, transmission media and procedures that ensures that a specific sequence of events occurs in a network in the proper order to produce the intended results.
Broadcasting	Messages are intended for all subscribers on the network.
Multicasting	Messages are intended for a specific group of subscribers.
Protocols	Defines the procedures that the systems involved in the communications process will use.
Data Communications Protocols	Sets of rules governing the orderly exchange of data within the network or a portion of the network.
Protocol Stack	The list of the protocols used by a system.
Layered Network Architecture	It consists of two or more independent levels.
Connection Oriented or Connectionless	A logical connection is established between the endpoints prior to the transmission of data.
Connection-Oriented Protocol	They are designed to provide a high degree of reliability for data moving through the network.
Handshake	A connection process that occurs between two stations before any data are actually transmitted. <u>Another terms:</u> <ul style="list-style-type: none"> • Sessions • Virtual circuits • logical connections
Syntax	It refers to the structure or format of the data within the message, which includes the sequence in which the data are sent.
Data Communications Standards	Guidelines that have been generally accepted by the data communications industry. <u>Types of standards:</u> <ul style="list-style-type: none"> • Proprietary system -open • open system
Proprietary	Generally controlled and manufactured by one company.

Standard	
International Standards Organization (ISO)	The international organization for standardization on a wide range of subjects.
American National Standard Institute (ANSI)	The member of ISO from the United States.
International Telecommunications Union	It is formerly CCITT; one of four permanent parts is based in Geneva, Switzerland.
V series	Modem interfaces and data transmission over the telephone lines.
X series	Data transmission over public digital Network, e-mail and directory services.
Institute of Electrical & IEEE) and Electronics Engineers	An international professional organization founded in the United States and is comprised of electronics, computer and communications engineers.
Electronics Industry Association (EIA)	A non-profit U.S. trade association that establishes and recommends industrial standards.
Telecommunications Industry Association	The leading trade association in the communications and information technology industry.
Advanced Research Projects Agency (ARPA)	The research arm of the Department of Defense in 1957.
Internet Engineering Task Force (IETF)	A large international community of network designers, operators, vendors and researches concerned with the evolution of the internet architecture and the smooth operation of the internet.
Internet Research Task Force (IRTF)	It promotes research of importance to the evolution of the future Internet by creating focused, long term and small research groups working on topics related to internet protocols.
Protocol data Unit (PDU)	A unit of data.
Encapsulation/Decapsulation	The process of adding and removing the PDU information.
Encapsulate	It means to place in a capsule or other protected environment.
Decapsulate	It means to remove from a capsule or other protected environment.

Service Access Point (SAP)	Defines which entity the service is intended.
Open Systems Interconnection (OSI)	<p>The name for the set of standards for communicating among computers</p> <p><u>Seven OSI layers:</u></p> <ul style="list-style-type: none"> • application • presentation • session • transport • network • data link • physical
Physical Layer	Responsible for the actual propagation of unstructured data bits through a transmission medium.
Data Link Layer	Responsible for providing error-free communications across the physical link connecting primary and secondary stations within a network.
Network Layer	Provides details that enable data to be routed between devices in an environment using multiple networks, sub network, or both.
Transport Layer	Controls and ensures the end-to-end integrity of the data message propagated through the network between two devices, which provides reliable, transparent transfer of data between two endpoints.
Session Layer	Responsible for network availability.
Presentation Layer	Provides independence to the application processes by addressing any code or syntax conversion necessary to present the data to the network in a common communications format.
Application Layer	It provides distributed information services and controls the sequence of activities within an application.
Station	An endpoint where subscribers gain access to the circuit.
Node	Another term of station which is the location of computers, computer terminals, workstations and other digital computing equipment.
Facilities	Interconnects digital computer equipment.
Source	Provides means to enter data from humans.
Transmitter	Encodes a wireless radio system without being converted to analog first.
Transmission Medium	Carries the encoded signals from the transmitter to the receiver.
Receiver	Converts the encoded signals received from the transmission medium back to their original form.
Destination	It could be a mainframe computer, personal computer workstation or virtually any piece of digital equipment

Parallel by Bit or Serial by Character	A type of transmission where all four bits can be transmitted simultaneously during the time of a single clock pulse.
Serial by Bit	Transmission where four clock pulses are required to transmit the entire four-bit code.
Two-Point Configuration	It involves only two locations or stations
Multi-point Configuration	It involves three or more stations.
Simplex	Data transmission is unidirectional where information can be sent in only one direction.
Simplex Lines	Also called Receive-Only, Transmit Only or One-way-only Lines
Half Duplex	Data transmission is possible in both directions but not at the same time. <u>Another term:</u> <ul style="list-style-type: none"> • two way alternate lines • either way lines
Full Duplex	Transmissions are possible in both directions two stations. simultaneously , but they must be between same <u>Another terms:</u> <ul style="list-style-type: none"> • Two-way simultaneous • duplex • both-way lines
Full/Full Duplex	Transmission is possible in both directions at the same time but not between the same two stations. It is possible only on multipoint circuits.
Networking	The process of sharing resources between computers over a data communication network.
Sneaker Net	The manual technique of moving data on disks.
Servers	Computers that hold shared files, programs and the network operating system.
Client	Computers that access and use the network and shared network resources.
Transmission Media	The facilities used to interconnect computers in a network.
Shared Data	Data that file servers provide to clients.
Shared Printers and other peripherals	Hardware resources provided to the users of the network by servers.

Network Interface Card (NIC)	An expansion card and prepares and sends data, receives data and controls data flow between the computer and the network.
Local Operating System (LOS)	Allows personal computers to access files, print to a local printer and have and use one or more disk and CD drives that are located on the computer.
Network Operating System (NOS)	A program that runs on computers and servers that allows the computers to communicate over a network.
Peer - to - Peer Client/ Server Network	One in which all computers share their resources.
Dedicated Client/Server Network	One computer is designated the server and the rest of the computers are clients.
Network Topology	Describes the layout or appearance of a network.
Physical Topology	Describes how the network is actually laid out
Logical Topology	Describes how data actually flow through the network
Star Topology	A multipoint data communications network where remote stations are connected by cable segments directly to a central located computer.
Bus Topology	A multipoint data communications circuit that makes it relatively simple to control data flow between and among the computers.
Ring Topology	A multipoint data communications network where all stations are interconnected in tandem to form a closed loop or circle.
Mesh Topology	Every station has a direct two-point communications link to every other station on the circuit.
Hybrid Topology	Combining two or more of the traditional topologies to form a larger, more complex topology.
Local Area Networks (LANs)	Privately own networks in which 10 to 40 compute share data resources with one or more file server.
Metropolitan Area Networks (MANs)	A high-speed network similar to a LAN except the are designed to encompass larger areas, usually that of an entire city.
Wide Area Network (WAN)	Provides low-speed, long distance transmission of data voice, and video information over large and widely dispersed geographical areas such as country or an entire continent. It interconnects cities or states.

1.5 Mbps-2.4 Gbps	Bit rate of WANs.
Global Area Network (GANs)	Provides connects between countries around the entire globe.
Building Backbone	A network connection that normally carries traffic between departmental LANs within a single company.
Campus Backbone	A network connection used to carry traffic to and from LANs located in various buildings on campus.
TCP/IP Protocol Suite	Developed by Department of Defense, comprise of several interactive modules that provide specific functionality.
Internet layer/ Internet work Layer	The network layer of TCP/IP.
Transmission Control (UDP) User datagram Protocol (TCP)	Transport layer of TCP/IP.
Network Access Layer	Provides a means of physically delivering data packets using frames or cells.
Internet Layer	Contains information that pertains to how data can be routed through the network.
Host-to-Host Layer	Serves the process and internet layers to handle the reliability and session aspects of data transmission.
Process Layer	Provides applications support.
Cisco Three-Layer Model	<p>Defines a three layer logical hierarchy that specifies where things belong, how they fit together and what functions go where.</p> <p><u>Three layers:</u></p> <ul style="list-style-type: none"> • Core layer • Distribution layer • access layer
Core Layer	The core of the network as it resides at the top of the hierarchy and is responsible for transporting large amounts of data traffic reliably and quickly.
Distribution Layer	The communications point between the access and the core layers that provide routing, filtering, WAN access and how data packets are allowed to access the core layer.

Workgroup Layer	Another term for Distribution layer
Access Layer	Controls workgroup and individual user access to internetworking resources.
Desktop Layer	Another term for Access layer.

CHAPTER 22: FUNDAMENTAL CONCEPTS OF DATA COMMUNICATIONS

TERMS	DEFINITIONS
Data Communications Codes	Often used to represent characters and symbols such as letters, digits and punctuation marks. <u>Another terms:</u> <ul style="list-style-type: none"> • character codes • character sets • symbol codes • character languages
Baudot Code	Sometimes called the Telex Code was the first fixed length character developed for machines rather than for people.
Thomas Murray	A French postal engineer who developed the baudot code in 1875 and named after Emile Baudot, an early pioneer in telegraph printing.
Fixed Length Block Code	Fixed-length source code.
USASCII	Stands for United States of America Standard Code for Information Exchange, better known as ASCII-63.
ASCII	The standard character set for source coding the alphanumeric character set that humans understand but computers do not (computers only understand 1s and 0s). It is a seven bit fixed-length character set.

Fixed Length Block Code	Fixed-length source code.
EBCDIC	Extended binary coded decimal interchange-code, an eight bit fixed length character developed in 1962 by International Business Machines Corporation.
Bar Codes	Omnipresent block and white striped stickers that seem to appear or virtually every consumer item in the US and most of the rest of the world.
Discrete Code	It has spaces or gaps between characters. Each character is independent of every other character.
Continuous Code	It does not include spaces between characters. An example is Universal Product Code.
2D code	It stores data in two dimensions in contrasts with conventional linear bar codes which stores data along only one axis.
Code-39	<p>It uses an alphanumeric code similar to ASCII code. It contains 9 vertical elements (5 bars & 4 spaces). It consists of 36 unique codes representing the 10 digits and 26 uppercase letters.</p> <p><u>Other Names:</u></p> <ul style="list-style-type: none"> • Code 3 of 9 • 3 of 9 code
Universal Product Code	A continuous code since there are no interchangeable spaces. Each UPC label contains a 12-digit number.
Start & Stop Guard Pattern	It consists of a 101 (bar-space-bar) sequence, which is used to frame the 12 digit UPC number.
Center Guard Frame	It separates the left and right halves of the label and consists of two

	long bars in the center of the label.
Transmission Errors	<p>Caused by electrical interference from natural sources</p> <p><u>Classification of Data Com Errors:</u></p> <ul style="list-style-type: none"> • single bit • multiple bit • burst <p><u>Categories of Error Control :</u></p> <ul style="list-style-type: none"> • Error Detection • Error Correction
Single Bit Errors	Errors with only one bit within a given a given string is in error.
Multiple-bit error	Errors with two or more non-consecutive bits within a message.
Burst Error	Errors when to or more consecutive bits within a given data string are in error. It can affect one or more characters within a message.
Probability of Error	The theoretical (Mathematical) expectation of the rate at which errors will occur.
Bit-Error Rate	The actual historical record of a system's error performance.
Error Detection	The process of monitoring data transmission and deter mining when errors have occurred. It neither corrects errors nor identifies which bits are in error-they only indicate when an error has occurred.
Redundancy Checking	<p>Adding of bits for the sole purpose of detecting errors</p> <p><u>Types of redundancy checks:</u></p> <ul style="list-style-type: none"> • vertical redundancy checking, • checksum, • longitudinal redundancy checking • cyclic redundancy checking

Redundancy	A form of error detection by duplicating each data unit for the purpose of detecting errors.
Parity	An error detection bit.
Vertical Redundancy Checking (VRC)	The simplest error-detection scheme and is generally referred to as character parity.
Parity Bit	An error detection bit in each character.
Marking Parity	The parity bit which is always a 1.
Ignored Parity	The parity bit which is not sent or checked
Checksum	Form of redundancy error checking where each character has a numerical value assigned to it.
Longitudinal Redundancy Checking (LRC)	A redundancy error detection scheme that uses parity to determine if a transmission error has occurred with n a message.
Message Parity	An error occurred within a message.
Block or Frame of Data	The group of characters that comprise a message
Block Check Sequence (BCS) or Frame Check Sequence (FCS)	The bit sequence for the LRC.
Cyclic Redundancy Checking	A convolution coding scheme that is most reliable redundancy checking technique for error detection. Almost 99.999% of all transmission errors are detected
	Types of Error Messages.

Lost Message Damaged Message	
Lost message	One that never arrives at the destination or one that is damaged to the extent that it is unrecognizable.
Damaged Message	One that is recognized at the destination but contains one or more transmission errors.
Error-Detecting Codes	<p>It includes enough redundant information with each transmitted message to enable the receiver to determine when an error has occurred.</p> <p><u>Examples:</u></p> <ul style="list-style-type: none"> • Parity bits • block and frame check characters • cyclic redundancy characters
Error-correcting Codes	<p>It includes sufficient extraneous information along with each message to enable the receiver to determine when an error has occurred and which bits is in error.</p> <p><u>Two primary methods for error correction:</u></p> <ul style="list-style-type: none"> • Retransmission • Forward Error Correction
Retransmission	When a receive station requests the transmit station to resend a message when the message is received in error.
Automatic Repeat Request (ARQ) or Automatic Retransmission Request	<p>A two-way radio term which automatically a retransmission f the entire message.</p> <p><u>Types of ARQ:</u></p> <ul style="list-style-type: none"> • Discrete • Continuous

Acknowledgement	<p>The recipient of data sends a short message back to the sender acknowledging receipt of the last transmission.</p> <p><u>Types of acknowledgements:</u></p> <ul style="list-style-type: none"> • Positive • Negative
Line Turnarounds	A receive station becomes the transmit station such as when acknowledgments are sent or when retransmission are sent in response to a negative acknowledgment.
Discrete ARQ	It uses acknowledgments to indicate the successful or unsuccessful reception of data.
Continuous ARQ	It can be used when messages are divided into smaller lock or frames that are sequentially numbered and transmitted in succession, without waiting for acknowledgments between blocks.
Retransmission Time-Out	The sending station does not receive an acknowledgment after a predetermined length of time.
Selective Repeat	The destination station asynchronously requests the retransmission of specific frame of data and still be able to reconstruct the entire message once all frames have been successfully transported through the system.
Forward Error Correction (FEC)	The error-correction scheme that detects and corrects transmission errors when they are received without requiring a retransmission.
Richard W. Hamming	A mathematician, who was an early pioneer in the development of error-detection and correction procedures, developed the Hamming Code while working at Bell Telephone Laboratories.
Hamming Code	An error-correcting code used for correcting transmission errors in synchronous data streams. It requires the addition of overhead to the message, consequently increasing the length of a transmission.

Hamming Bits	Inserted into a character at random locations.
Hamming Code	The combination of the data bits and the hamming bits.
Synchronize	It means to harmonize, coincide, or agree in time.
Character Synchronization	Involves identifying the beginning and end of a character within a message.
Asynchronous	Its literal meaning is “without synchronism”. In Data Com, it means “without a specific time reference”
Start-stop Transmission	Asynchronous communications is called as such because each data character is framed between start and stop bits.
Clock Slippage	A condition when the transmit and receive clocks are substantially different
Under slipping	It occurs when the transmit clock is substantially lower than the receive clock.
Overslipping	Occurs when the transmit clock is substantially higher than the receiver clock.
Synchronous Data	It involves transporting serial data at relatively high speeds in groups of characters.
POTS	Plain old Telephone system
Data Communications System	It is comprised of three basic elements: transmitter (source) <ul style="list-style-type: none"> • transmission path (data channel) • receiver (destination)

	<u>3 fundamental components of endpoints:</u> <ul style="list-style-type: none"> • data terminal equipment • data communications equipment • serial interface
Data Terminal Equipment (DTE)	It can be virtually any binary digital device that generates transmits, receives, or interprets data messages. It is where information originates or terminates.
Terminal	Devices used to input, output and display information such as keyboards, printers and monitors
Client	Basically a modern-day terminal with enhance computing capabilities
Hosts	High-powered, high capacity mainframe computers that support terminals.
Servers	It functions as modern-day host.
Equipment (DCE) Data Communications	<p>A general term use to describe equipment that interfaces data terminal equipment to a transmission channel, such as a digital T1 carrier or an analog telephone circuit. It is a signal conversion device, as it converts signals from a DTE to a form more suitable to be transported over transmission channel.</p> <p><u>Types of DCE:</u></p> <ul style="list-style-type: none"> • channel service units (CSUs) • Digital service units (DSUs) • data modems
Data Circuit-Terminating Equipment (DCTE)	Another term for DCE.
Data Modem	A DCE used to interface a DTE to an analog telephone circuit

	commonly called POTS.
Cluster Controller	It controls data flow between several terminal devices and the data communications channel.
Station Controllers (STACOs)	Line control units at secondary stations.
UART	Universal Asynchronous Receiver/transmitter it is designed for asynchronous data transmission.
Asynchronous Communications Interface Adapter (ACIA)	A special purpose UART chip manufactured by Motorola.
Asynchronous Data Transmission	It means that an asynchronous data format is used and no clocking information transferred between the DTE and the DCE.
Status Word	An n-bit data register that keeps track of the status of the UART's transmits and receive buffer registers.
Transmit Buffer Empty (TBMT)	Transmit shift register has completed transmission of data character.
Receive Parity Error (RPE)	Set when a received character has a parity error in it.
Receive Framing Error (RFE)	Set when a character is received without any or with improper number of stop bits.
Receiver Overrun (ROR)	Set when a character in the receive buffer register is written over by another receive character.
Receive Data Available	A data character has been received and loaded into the receive data register.

(RDA)	
Detection Error	The difference in time between the beginning of a start bit and when it is detected.
Universal Synchronous Receiver/transmitter (USRT)	<p>It is used for synchronous transmission of data between a DTE and a DCE.</p> <p><u>Functions of USRT:</u></p> <ul style="list-style-type: none"> • Serial to parallel and parallel to serial data conversions • Error detection by inserting parity bits in the transmitter and checking parity bits in the receiver. • Insert and detect unique data synchronization (SYN) characters • Formatting data in the transmitter and receiver. • Provide transmit and receive status information to the CPU. • Voltage-level conversion between the DTE and the serial interface and vice versa. • Provide a means of achieving bit and character synchronization.
Serial Interface	<p>It should provide the ff:</p> <ul style="list-style-type: none"> • A specific range of voltages for transmit and receive signal levels • Limitations for the electrical parameters of the transmission line. • Standard cable and cable connectors • Functional description of each signal on the interface. •
Electronics Industries Association (EIA)	In 1962, standardized the interface equipment between data terminal equipment and data communications equipment.
RS	It means "Recommended Standards"
Interface Between Data Terminal Equipment and Data Communications Equipment Employing Data Communications	The official name of the RS-232 interface

Equipment Employing Serial Binary Interchange	
RS-232C	In, 1969, the third revision which was published and remained the industrial standard until 1987.
RS-232D	Sometimes referred to as the EIZ-232 standard Versions D and E of the RS-232 standard changed some of the pin designations.
RS-232 Cable	<p>It is a sheath containing 25 wires with a DB25P-compatible male connector (plug) on one end and a DB25S-compatible female connector (receptacle) on the other end.</p> <p><u>Two full-duplex channels:</u></p> <ul style="list-style-type: none"> • Primary data-actual information • secondary data-diagnostic information and handshaking signals
9-pin Version of RS-232	It is designed for transporting asynchronous data between a DTE and a DCE or between DTEs .
25 pin Version	It is designed for transporting either synchronous or asynchronous data between a DTE and a DCE.
EIA-561	<p>It is designed exclusively for dial-up telephone.</p> <p>It is used for transporting asynchronous data between a DTE and a DCE when the DCE is connected directly to a standard two-wire telephone line attached to the public switched telephone network.</p>
Voltage-Leveling Circuits	It converts the internal voltage levels from the DTE and DCE to RS-232 values.
Driver	A voltage leveler wherein its output signals onto the cable.
Terminator	It accepts signals from the cable.

<u>FUNCTIONS OF RS-232 PINS</u> Pin 1	Protective ground, frame ground, or chassis ground.
Pin 2	Transmit data or send data.
Pin 3	Receive data (RD or RxD)
Pin 4	Request to send (RS or RTS)
Pin 5	Clear to send.(CS or CTS)
Pin 6	Data set ready or modem ready.(DSR or MR)
Pin 7	Signal ground or reference ground.
Pin 8	Unassigned and non-EIA specified often held at +12V
Pin 9	Receive line signal detect, carrier detect or data carrier detect (RLSD, CD or DCD)
Pin 10	Unassigned and often held at -12 Vdc for test purposes
Pin 12	Secondary receive line signal detect, secondary carrier detect or secondary data carrier detect (SRLSD, SCD, or SDCD)
Pin 13	Secondary clear to send.
Pin 14	Secondary transmit data or secondary send data
Pin 15	Transmission signal element timing or serial Clock transmit.

Pin 16	Secondary received data
Pin 17	Receiver signal element timing or serial clock receive
Pin 18	Unassigned is used for local loopback signal
Pin 19	Secondary request to send
Pin 20	Data terminal ready.
Pin 21	Signal quality detector.
Pin 22	Ring indicator (RI)
Pin 23	Data signal rate selector (DSRS)
Pin 24	Transmit signal element timing or serial clock transmit-DTE
Pin 25	Unassigned. It is sometimes used as a control signal from the DCE to the DTE to indicate that the DCE is in either the remote or local loop back mode.
RS-449 Serial Interface	<p>It specifies a 37-pin primary connector DB37 and a 9 pin secondary connector DB9 for a total of 46 pins which provides more functions, faster data transmission rates and spans greater distances than the RS-232.</p> <p><u>Primary goals of RS-449:</u></p> <ul style="list-style-type: none"> • Compatibility with the RS-232 interface standard • Replace the set of circuit names and mnemonics

	<ul style="list-style-type: none"> • Provide separate cables and connectors • Reduce crosstalks • offer higher data transmission • longer distances over twisted pair cables • loopback capable • improve performance and reliability <p>specify a standard connector</p> <p><u>Two categories:</u></p> <ul style="list-style-type: none"> • Category I • Category II
<u>10 CIRCUITS IN RS-485</u>	
1. Local Loopback	Used by the DTE to request a local loopback from the DCE.
2. Remote Loopback	Used by the DTE to request a remote loopback from the distant DCE.
3. Select frequency	Allows the DTE to select the DCE's transmit and receive frequencies.
4. Test Mode	Used by DTE to signal the DCE that a test is in progress.
5. Receive Common	Common return wire for unbalanced signals propagating from the DCE to the DTE
6. Terminal in Service	Used by the DTE to signal the DCE whether it is operational
7. Select Standby	Used by the DTE to request that the DCE switched to standby equipment.
8. New Signal	Used with a modem at the primary location of a multipoint data circuit.
RS-530 Serial Interface	It was intended to operate at data rates between 20 kbps and 2 Mbps using the same DB25 connector

Data Communications Modem	<p>It is used to interface computers, computer networks to analog transmission media</p> <p><u>Alternate names:</u></p> <ul style="list-style-type: none"> • datasets • dataphones • modems
Modem	<p>A contraction derived from the words Modulator and Demodulator.</p> <p><u>Primary Block of a Modem:</u></p> <ul style="list-style-type: none"> • Serial interface Circuit • Modulator Circuit • Bandpass filter and equalizer circuit • telco interface circuit • demodulator circuit • carrier and clock generation circuit
Voice-band Modem	Data communications modems designed to operate over the limited bandwidth of the PSTN.
Broadband Modem	It is able of transporting higher bit rates.
DAC	Digital to analog converter.
ADC	Analog to digital converter.
Baud	It is a rate of change of signals on the transmission medium after encoding and modulation have occurred
Bit Rate	Refers to the rate of change of a digital information signal.
Asynchronous Modems	It is classified as low-speed voice-band modems

Isochronous Transmission	Synchronous data transported by asynchronous modems.
Synchronous Modems	It uses PSK or quadrature amplitude modulation to transport data.
Training Sequence	A special, internally generated bit pattern in transmit modem.
Compromise Equalizers	Located in the transmit section of a modem and provide pre-equalization
Adaptive Equalizer	Located in the receiver section of a modem where they provide post-equalization to the received signals
ITU-T V.29	The first internationally accepted standard for 9600bps data transmission rate.
V.29 Standard	It is intended to provide synchronous data transmission over four-wire leased lines.
Quin bits	Five bits.
Echo Cancellation	A technique for full-duplex operation over two wire switched telephone lines.
V.32 Specification	It addresses asynchronous-to synchronous transmission conversions and error control that includes both detection and correction. It specifies a new protocol called Link Access Procedures for Modems.
V.fast	<p>It is the next generation data transmission with data rates of 28.8 Kbps without compression possible using V.34.</p> <p><u>V.34 Innovations:</u></p> <ul style="list-style-type: none"> • Nonlinear coding • multidimensional coding and constellation shaping • Reduced complexity • precoding of data • line probing

V.34+	An enhanced standard adopted by ITU in 1996. It adds 31.2 kbps and 33.6 kbps to the V.34 specification.
V.90 Recommendation	Developed by ITU-T in February 1998 during a meeting in Geneva, Switzerland. It defines an asymmetrical data transmission technology where the upstream 33.6kbps and downstream of 56kbps.
V.92 Recommendation	<p>A new modem standard in 2000 which offers 3 improvements over V.90 that can be achieved only if both the transmit and receive modems and the internet Service Provider (ISP) are compliant.</p> <p><u>It offers:</u></p> <ul style="list-style-type: none"> • upstream transmission rate of 48 kbps • faster call setup capabilities • incorporation of a hold option

CHAPTER 23: DATA-LINK PROTOCOLS AND DATA COMMUNICATIONS NETWORKS

TERMS	DEFINITIONS
Network Architecture	The primary goal of _____ is to give users of a network the tools necessary for setting up the network and performing data flow control.
Data-Link Protocol	A set of rules implementing and governing an orderly exchange of data between two layer devices.
Master Station	The transmitting station in a data link protocol.
Slave Station	The receiving station in a data link protocol.
Peer-to Peer Network	Data link network wherein all stations have equal access to the network.
Functions of Data-link Protocol	Discipline, Flow Control and Error Control.
Line Discipline	Coordinates hop-to-hop data delivery where a hop may be a computer, a network controller, or some type of network-connecting device

Line Discipline	Determines which device is transmitting and which is receiving at any point in time.
Flow Control	Coordinates the rate which data are transported over a link and generally provides an acknowledgement mechanism.
Error Control	Specifies means of detecting and correcting transmission errors.
Enquiry/Acknowledgement (ENQ/ACK) and Poll/Select	Two fundamental ways that line discipline is accomplished in a data communications network.
ENQ/ACK	It determines which device on the network can initiate a transmission and whether the intended receiver is available and ready to receive a message.
Enquiry (ENQ)	The initiating station begins a session by transmitting a frame, block, or packet of data called _____, which identifies the receiving station.
Positive Acknowledgement (ACK)	The response of the destination station when it is ready to receive.
Negative Acknowledgement (NAK)	The response of the destination station when it is not ready to receive.
Centrally Controlled Data Network	The best application of the poll/select line discipline.
Poll	A solicitation sent from the primary to a secondary to determine if the secondary has data to transmit
Flow Control	A set of procedures that tells the transmitting station how much data it can send before it must stop transmitting and wait for an acknowledgment from the destination station
Stop-and Wait Flow Control	The transmitting station sends one message frame and then waits for an acknowledgement before sending the next message frame.
Sliding Window Flow Control	A source station can transmit several frames in succession before receiving an acknowledgement.
Sliding Window	It refers to imaginary receptacles at the source and destination stations with the capacity of holding several frames of data.
Network Utilization	Primary advantage of sliding window control.
Complexity and Hardware Capacity	Primary disadvantages of sliding window flow control.
Character Oriented Protocols	Interpret a frame of data as a group of successive bits combined into predefined patterns of fixed length, usually eight bits each.
Byte-oriented Protocols	Another name for character oriented protocols.
Bit Oriented	A discipline for serial by bit information transfer over a data communications channel.

Protocol	
Asynchronous Data link Protocols	A character-oriented protocols generally used on two point networks using asynchronous data and asynchronous modems.
Ward Christiansen	Developed the first file transfer protocol designed to facilitate transferring data between two personal computers in 1979.
XMODEM	Cristiansen's protocol which is relatively simple data link protocol intended for low-speed applications.
Synchronous Data-Link Protocols	Remote stations can have more than one PC or printer.
Cluster	A group of computers, printers, and other digital devices.
Binary Synchronous Communications (BSC)	A synchronous character-oriented data link protocol developed by IBM.
Bisync	Another name for BSC.
Format or line turn around	Another name for enquiry (ENQ) character.
Block Check Character (BCC)	The _____ uses longitudinal redundancy checking (LRC) with ASCII-coded messages and cyclic redundancy checking.
Synchronous Data-Link Control (SDLC)	A synchronous bit oriented protocol developed in the 1970's by IBM for use in system network architecture environment.
Transient, Idle and Active	Three transmission states.
SDLC Frame Fields	Flag Fields, Address Field, Control Field, Information and Frame Check Sequence Field are _____.
Flags	It is used for the delimiting sequence for the frame and to achieve frame and character synchronization.
Control Field	It is used for polling, confirming previously received frames, and several other data link management functions
Information, Supervisory and Unnumbered	Three frame formats with SDLC.
Unnumbered Information (UI)	A command or a response that is used to send unnumbered information.
Set Initialization Mode	A command that places a secondary station into the initialization mode.
Request Initialization Mode (RIM)	A response sent by a secondary station to request the primary to send a SIM command.
Set Normal Response Mode	A command that places a secondary into the normal response mode.

(SNRM)	
Disconnect Mode (DM)	A response transmitted from a secondary station if the primary attempts to send numbered information frames to it when the secondary is in the normal disconnect mode.
Request Disconnect (RD)	A response sent by a secondary when it wants the primary to place it in the disconnect mode.
Unnumbered Acknowledgement	An affirmative response that indicates compliance to SIM, SNRM or DISC commands
TEST	An exchange of frames between the primary station and a secondary station.
Turnaround Sequence	A flag followed by eight consecutive logic 0's.
Clear	A SDLC subcommand causes all previously set functions to be cleared by the secondary.
Beacon Test	A SDLC subcommand causes the secondary receiving it to turn on or turn off its carrier.
Monitor Mode	A SDLC command causes the addressed secondary station to pace itself into the monitor mode.
Wrap	A SDLC command causes a secondary station to loop its transmission directly to its receiver input.
Self-Test	A SDLC command causes the addressed secondary to initiate a series of internal diagnostic tests.
Zero Bit Insertion or Zero Stuffing	The transparency mechanism used with SDLC.
Message Abort	It is used prematurely terminate an SDLC frame.
Invert-On-Zero Coding	The encoding scheme used in SDLC.
ISO 3309	Standard that defines the frame structure, delimiting sequence, transparency mechanism and error detection method used with HDLC.
Normal Response Mode (NRM)	Operational Mode of SDLC.
Asynchronous Balanced Mode	A mode of operation logically equivalent to a two point private line circuit where each station has equal data link responsibilities.
Public Switched Data Network (PDN)	A switched data communications network similar to the public telephone network except a PDN is designed for transferring data only.
Circuit Switching	It is used when making a standard telephone call on the public telephone network.
Message Switching	Is a form of store and forward network.

Hold and Forward Network	Another name for packet switching.
X.25	A user interface as the international standard for packet network access.
Permanent Virtual Circuit (PVC)	SA logically equivalent to a two point dedicated private line circuit except slower.
Virtual Call	A logically equivalent to making a telephone call through the DDD network except no direct end to end connection is made.
Format Identifier	Identifies whether the packet is a new call request or a previously established call.
Logical Channel Identifier	A 12 bit binary number that identifies the source and destination users for a given virtual call.
Calling Address Field	This four bit gives the number of digits that appear in the calling address field.
Called Address Length	This field is the same as the calling address field except that it identifies the number of digits that appear in the called address field
Called Address	This field contains the destination address.
Calling Address	This field is the same as the called address field except that it contains up to 15 BCD.
Facilities Length Field	This field identifies the number of eight bit octets present in the facilities field.
Protocol Identifier	This 32 bit field is reserved for the subscriber to insert user level protocol.
Integrated Services Digital Network (ISDN)	A proposed network designed by the major telephone companies in conjunction with the ITU-T.
Digital Pipe	Customers gain access to the ISDN system through a local interface connected to a digital transmission medium.
System Standardization	ISDN objectives that ensure universal access to the network.
Achieving Transparency	Said objectives that allow customers to use a variety of protocols and applications
Separating Functions	ISDN should not provide services that preclude competitiveness
Variety of Configurations	Provide private-line and switched services refer what objectives of ISDN.
Addressing Cost-Related Tariffs	ISDN services should not be directly related to cost and independent of the nature of the data.
Migration	Provide a smooth transition while evolving.
Multiplexed Support	Provide service to low capacity personal subscribers as well as to large

	companies.
Terminal Adapter	Translation between non-ISDN data protocol and ISDN is performed in this device.
Network Termination 1	A boundary to the network and may be controlled by the ISDN provider.
U-Reference Point	Refers to interfaces between the common carrier subscriber loop and the central office switch
U Loop	The media interface point between an NT1 and the central office.
Broadband ISDN	It is defined by ITU-T as a service that provides transmission channels capable of supporting transmission rates greater than the primary data rate.
Distribution Services	Information transfer is primarily from service provider to subscriber
Broadband Node	Codes the data information into smaller packets used by the BISDN network
Virtual Channel	A connection between a source and a destination, which may entail several ATM links.
Cells	Once data have entered the ATM network, they transferred into fixed time slots called _____.
Generic Flow Control Field (GFC)	Controls the flow of traffic across the user network interface (UNI) and into the network.
Payload Type Identifier	The first three bits of the second half of byte 4 specify the type of message in cell.
Constant Bit Rate	Information fields that are designed to accommodate PCM-TDM traffic, which allows the ATM, network to emulate voice or DSN services.
Public ATM Switches	A portion of a public service provider's switching system where the service provider could be a local telephone company or a long-distance carrier.
Local Area Networks (LAN)	Provides the most effective and economical means of handling local data communications field.
E-Mails	A communications system that allows users to send messages to each other through their computers.
Star, Bus and Ring Topology	LAN Topologies.
Network Access Methodologies	It describes how users access the communications channel in a LAN.
CDMA/CD	Access method used primarily in bus topology.
Collision	It two stations transmit at the same time, _____ occurs.
Propagation Delay	The time it takes a signal to travel from a source to a destination.

Ethernet	A base band transmission system designed in 1972 by Robert Metcalfe and David Boggs.
Preamble	Its purpose is to establish clock synchronization.
Start Frame Delimiter	It is simply a series of two logic 1's appended to the end of the preamble.
Source Address	Consists of six bytes the corresponds to the address of the station sending the frame.

CHAPTER 24: MICROWAVE RADIO COMMUNICATIONS AND SYSTEM GAIN

Microwaves	Electromagnetic waves with frequencies that range from approximately 500 MHz to 300 GHz or more.
1 cm and 60 cm slightly longer	The wavelengths for microwave frequencies, which is than infrared energy.
“Microwave” waves	The name given to microwave signals, because of their inherently high frequencies, has short wavelengths.
Full-Duplex (Two-way)	Each frequency is divided in half with the lower half identified as the <i>low band</i> and the upper half as <i>narrow band</i> .
Short Haul	Communications system used to carry information for relatively short distances such as between cities with the same state.
Long Haul	Microwave systems that is used to carry information for relatively long distances, such as interstate and backbone route applications.
Microwave Radios	<p>It propagate signals through Earth's atmosphere between transmitters and receivers often located on top of tower spaced about 15 miles to 30 miles apart.</p> <p><u>Advantages of Microwave Radio:</u></p> <ul style="list-style-type: none"> • Radio systems do not require a right-of way acquisition between stations. • Each station requires the purchase or lease of only a small area of land. • Because of their high operating frequencies, microwave radio systems can carry large quantities of information. • High frequencies mean short wavelengths, which require

	<p>relatively small antennas.</p> <ul style="list-style-type: none"> • Radio signals are more easily propagated around physical obstacles such as water and high mountains • Fewer repeaters are necessary for amplification. • Distances between switching centers are less. • Underground facilities are minimized. • Minimum delays are introduced. • Minimal crosstalk exists between voice channels. • Increased reliability and less maintenance are important factors. <p><u>Disadvantages of Microwave Radio:</u></p> <ul style="list-style-type: none"> • It is more difficult to analyze and design circuits at microwave frequencies. • Measuring techniques are more difficult to perfect and implement at microwave frequencies. • It is difficult to implement conventional circuit components at microwave frequencies. • Transient time is more critical at microwave frequencies. • It is often necessary to use specialized components for microwave frequencies. • Microwave frequencies propagate in a straight line, which limits their use to line-of-sight applications.
Satellite Systems	Propagates signals outside the Earth's atmosphere and are capable of carrying signals much farther while utilizing fewer transmitters and receivers.
Frequency Modulation	It is used in microwave radio systems rather than amplitude modulation because AM signals are more sensitive to amplitude nonlinearities inherent in <i>wide-band microwave amplifiers</i> .
Intermodulation Noise	Major factor when designing FM Radio systems. It is caused by repeater amplitude nonlinearity in AM, while in FM, it is caused by transmission gain and delay distortion.
Baseband	<p>The composite signal that modulates the FM carrier and may comprise one or more of the following:</p> <ul style="list-style-type: none"> • Frequency-division multiplexed voice-band channels • Time-division-multiplexed voice-band channels • Broadcast-quality composite video or picture phone • Wideband data
Preemphasis Network	It provides an artificial boost in amplitude to the higher baseband frequencies.
Low-Index	Frequency modulation index used in the FM deviator. Typically, modulation indices are kept between 0.5 and 1.
Narrowband FM	FM signal that is produced at the output of the deviator with a low-index frequency modulation.
Microwave Repeaters	A receiver and a transmitter placed back to back or in tandem with the system.

Repeater Station	<p>It receives a signal, amplifies and reshapes it, and then retransmit the signal to the next repeater or terminal station down line from it.</p> <p><u>Types of Microwave repeaters:</u></p> <ul style="list-style-type: none"> • IF • Baseband • RF
IF Repeater	The received RF carrier is down-converted to an IF frequency, amplified, reshaped, up-converted to an RF frequency, and then retransmitted.
Baseband Frequencies	Generally less than 9 MHz
IF frequencies	The range is 60 MHz to 80 MHz.
Shift Oscillator	Another name for a Local oscillator is considerably lower in frequency than either the received or the transmitted radio frequencies.
Line-of Site Transmission	Transmission used by microwave systems wherein a direct signal path must exist between the transmitter and receiver.
Radio Fade	A temporary reduction in signal strength which lasts in milliseconds for several hours or even days.
Diversity	It suggests that there is more than one transmission path or method of transmission available to a transmitter and a receiver.
Frequency Diversity	It is simply modulating two different RF carrier frequencies with the same IF intelligence, then transmitting both RF signals to a given destination.
Space Diversity	The output of a transmitter is fed to two or more antennas that are physically separated by an appreciable number of wavelengths.
Polarization Diversity	A single RF carrier is propagated with two different electromagnetic polarizations. It is generally used in conjunction with space diversity.
Receiver Diversity	It is more than one receiver for a single radio-frequency channel. With frequency diversity, it is necessary to also use receiver diversity because each transmitted frequency requires its own receiver.
Quad Diversity	Another form of Hybrid diversity and undoubtedly provides the most reliable transmission but is most expensive. It combines frequency, space, and polarization and receiver diversity into one system.
Hybrid Diversity	A specialized form of diversity that consists of a standard frequency diversity path where the two transmitter/receiver pairs at one end of the path are separated from each other and connected to different antennas that are vertically separated as in space diversity.
Protection Switching Arrangement	<p>Alternate facilities temporarily made to avoid a service interruption during periods of deep fades or equipment failures.</p> <p><u>types of protection switching arrangements:</u></p> <ul style="list-style-type: none"> • hotstandby

	<ul style="list-style-type: none"> diversity
Hot Standby Protection	Each working radio channel has a dedicated backup or spare channel.
Diversity Protection	A single backup channel is made available to as many as 11 working channels.
Head-End Bridge	In hotstandby protection, it splits the signal power and directs it to the working and the spare (standby) microwave channels simultaneously.
Diversity Protection	It has two working channels, one spare channel, and an auxiliary channel.
Auxilliary Channel	A low-capacity low-power microwave radio that is designed to be used for a maintenance channel only.
Reliability Objectives of the Systems	It is where the number of repeater stations between protection switches depends.
Terminal Stations	<p>Points in the system where baseband signals either originate or terminate. <u>four major sections:</u></p> <ul style="list-style-type: none"> baseband wireline entrance link (WLEL) FM-IF RF sections
Repeater Stations	Points in a system where baseband signals may be reconfigured or where RF carriers are simply "repeated" or amplified.
WLEL	Stands for WireLine Entrance Link, it serves as the interface between the multiplex terminal equipment and the FM_IF equipment.
Transmod	A balanced modulator that, when used in conjunction with a microwave generator, power amplifier, and band-pass filter, up-converts the IF carrier to an RF carrier and amplifies the RF to the desired output power.
Power Amplifiers	<p>It must be capable of amplifying very high frequencies and passing very wide bandwidth signals for microwave radios.</p> <p><u>devices used in microwave amplifiers:</u></p> <ul style="list-style-type: none"> Klystron Tubes Traveling-wave tubes (TWTs) IMPATT (Impact avalanche and transit time)
Microwave Generator	It provides the RF carrier input to the up-converter. It is called as microwave generator rather than an oscillator because it is difficult to construct a stable circuit that will oscillate in the gigahertz range.
Crystal-controlled Oscillator	It operates in the range 5 MHz to 25 MHz, used to provide a base frequency that is multiplied up to the desired RF carrier frequency.

Isolator	A unidirectional device often made from ferrite material. It used in conjunction with a channel-combining network to prevent the output of one transmitter from interfering with the output of another transmitter.
AGC	Stands for Automatic Gain Control, is a circuit in an IF amplifier.
Multi-hop Interference	It occurs only when three stations are placed in a geographical straight line in the system.
High/Low-Frequency Scheme	It prevents the power that "leaks" out the back and sides of a transmit antenna from interfering with the signal entering the input of a nearby receive antenna.
Ring around	The signal entering the input of a nearby receive antenna.
V Channels	It means that this channel is propagated with vertical polarization.
Free-Space Path	The line-of-sight directly between the transmit and receive antenna. Also called as the Direct Wave.
Surface Wave	It consists of the electric and magnetic fields associated with the currents induced in earth's surface.
Ground-Reflected Wave	The portion of the transmit signal that is reflected off Earth's surface and captured by the receive antenna.
Sky Wave	The portion of the transmit signal that is returned back to Earth's surface by the ionized layers of earth's atmosphere.
Free-Space Path Loss	The loss incurred by an electromagnetic wave as it propagates in a straight line through a vacuum with no absorption or reflection of energy from nearby objects.
Spreading Loss	A phenomenon wherein electromagnetic energy is spread out as it propagates away from the source resulting in lower relative power densities.
Fading	The reduction in signal strength at the input to a receiver.
System Gain	The difference between the nominal output power of a transmitter and the minimum input power to a receiver necessary to achieve satisfactory performance.
Fade Margin	Sometimes called as Link Margin, is essentially a "fudge Factor" included in system gain equations that considers the non ideal and less predictable characteristics of radio wave propagation and terrain sensitivity.
W.T. Barnett	He described ways of calculating outage time due to fading on a non diversity path as a function of terrain, climate, path length, and fade margin, in April 1969.
Arvids Vignat	From Bell Laboratories, he derived formulas for calculating the effective improvement achievable by vertical space diversity as a function of the spacing distance, path length, and frequency in June 1970.

Carrier-to-Noise Ratio (C/N)	The ratio of the wideband “carrier” to the wideband noise power.
Receiver Threshold	Also called Receiver Sensitivity, is the minimum wide band carrier power at the input to a receiver that will provide a usable baseband output.
Pre-detection Signal to-Noise Ratio	The carrier-to-noise ratio before the FM demodulator.
Postdetection Signal-to-Noise Ratio	The carrier-to-noise ratio after the FM demodulator.
Noise Factor (F)	A ratio of input signal-to-noise ratio to output signal to noise ratio.
Noise Figure	The noise factor stated in dB and is a parameter commonly used to indicate the quality of a receiver.

CHAPTER 25: SATELLITE COMMUNICATIONS

TERMS	DEFINITION
Satellite	A celestial body that orbits around a planet.
Communications Satellites	Man-made satellites that orbit earth, providing a multitude of communication functions to a wide variety of consumers, including military, governmental, private and commercial subscriber.
Transponder	A satellite radio repeater is called?
Satellite System	It consists of one or more satellite space vehicles, a ground-based station to control the operation of the system, and a user network of earth stations that provides the interface facilities for the transmission and reception of terrestrial communications traffic through the satellite system.
Bus	It includes control mechanism that supports the payload operation.
Payload	The actual user information conveyed through the system.
Passive Reflector	A type of satellite wherein it simply “bounces” signals from one place to another.
Moon	A natural satellite of Earth, visible by reflection of sunlight having a slightly elliptical orbit.
Radio Beacon Transmitters	Used by passive satellites for tracking and ranging purposes.

Sputnik I	Launched by Russia, the first active earth satellite in 1957. It transmitted telemetry for 21 days.
Active Satellite	A type of satellite capable of receiving, amplifying, reshaping, regenerating and retransmitting information.
Explorer I	Satellite launched by U.S., it transmitted telemetry information for nearly five months.
Score	Satellite launched by NASA in 1958, a 150-pound conical-shaped satellite. It was the first artificial satellite used for relaying terrestrial communications.
Delayed Repeater Satellite	The score is type of satellite were in the received transmission from earth station, stored them on a magnetic tape, and then rebroadcast them later to ground station farther along in its orbit.
Echo	Launched by the NASA in junction with Bell Telephone Laboratories and the jet Propulsion Laboratory. It is passively reflected radio signal it received from large earth station antennas and it was simple and reliable radio signal but required extremely high power transmitter at the earth station.
Courier	In 1960 the Department of Defense launched a satellite which was the first transponder type satellite and has transmitted 3W of power and lasted only 17 days.
Telstar I	The first active satellite to simultaneously receive and transmit radio signals.
Telstar II	Launched in 1963, and was used for telephone, television, facsimile and data transmission and accomplished the first successful transatlantic video transmission.
Syncom I	Launched in February 1963, was the first attempt to place a geosynchronous satellite into orbit.
Syncom III	The satellite used to broadcast the 1964 Olympic Games from Tokyo Japan.
Syncom	The satellite that demonstrate the feasibility of using geosynchronous satellite.
Intelsat I	It was the first commercial telecommunications satellite. It launched from Cape Kennedy in 1965 and used two transponders. Also called as Early Birds. It stands for International Telecommunications Satellite.
Molniya	Domestic satellite launched by former Soviet Union in 1966. It means "lightning".
Johannes Kepler	A German astronomer who discovered the laws that governs satellite motion.
<p style="text-align: center;">Kepler's Law</p> <ul style="list-style-type: none"> ➤ The planets move in ellipses with the sun at one focus. ➤ The line joining the sun and the planet sweeps out equal intervals of time. ➤ The square of the time of revolution of a planet divided by the cube of its mean distance from the number that is the same for all planets. 	

Kepler's Second Law	Enunciated with the first law in 1609, is known as law of area, this law states that for equal intervals of time a satellite will sweep out equal area in the orbital plane, focused at the barycenter.
Perigee	The point in an orbit closest to earth.
Apogee	The point in an orbit farthest from the earth.
Harmonic Law or Kepler's Third Law $a = AP^{2/3}$ a = semimajor axis P = mean solar earth station A = constant	It states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the primary and the satellite.
Geosynchronous Satellite	High-altitude earth-orbit satellites operating primarily in the 2-GHz to 18 GHz frequency spectrum with orbits Satellite 22,300 miles above earth's surface.
<p style="text-align: center;">Advantages of Geosynchronous Satellite:</p> <ul style="list-style-type: none"> ➤ It remain almost stationary in respect to a given earth station. ➤ Available to earth within their shadows 100% of the time. ➤ No need to switch from one geosynchronous satellite to another as they orbit overhead ➤ The effects of Doppler shift are negligible <p style="text-align: center;">Disadvantages of geosynchronous Satellite:</p> <ul style="list-style-type: none"> ➤ It requires sophisticated and heavy propulsion device onboard to keep them in a fixed orbit ➤ Much longer propagation delays ➤ Requires higher transmit power and more sensitive receivers because of the longer distances and greater path loss. ➤ High precision spacemanship is required. 	
Nonsynchronous	Satellite that rotates around the earth in an elliptical or circular patterns.
Prograde or Posigrade	If the satellite is orbiting in the same direction as earth's rotation and at the angular velocity greater than the earth that orbit is called?
Retrograde	If the satellite is orbiting in the same direction as earth's rotation and at the angular velocity less than the earth that orbit is called?
Low Earth Orbit (LEO)	The satellite operates in the 1.0GHz to 2.5GHz frequency range and utilizing a 66-satelite constellation orbiting approximately 48 miles above the earth's surface.
Medium Earth Orbit (MEO)	The satellite operates in the 1.2GHz to 1.66GHz frequency band and orbit between 6000 miles and 12000 miles above the earth.
Geosynchronous Earth Orbit (GEO)	The satellite are high altitude earth orbit satellite operating primary in the 2GHz to 18 GHz frequency spectrum with orbits 22,300 miles above the earth's surface.
Geostationary	Those that orbit in a circular pattern with a angular velocity equal to the earth.

Near-Synchronous	It is slightly lower than 22,300 miles above earth, the satellite orbit time is lower than earth's rotational period.
Major Axis	The line joining the perigee and apogee through the center of the earth and sometimes called line of apsides .
Minor Axis	The line perpendicular to the major axis and halfway between the perigee and apogee it is sometimes called semiminor axis.
Geocenter	All satellite rotate around the earth in an orbit that from a plane that passes through the center of the gravity of earth is called?
Inclined Orbits	Are virtually all orbits except those that travel directly above the equator or directly over the north and south poles?
Angle of Inclination	The angle between the earth's equatorial plane and the orbital plane of a satellite measured counter clockwise at the point in the orbit where it crosses the equatorial plane traveling from south to north called the ascending node .
Descending Node	The point where a polar or inclined orbit crosses the equatorial plane traveling from north to south is called?
Line of Nodes	The line joining the ascending and descending nodes through the center of the earth is called?
Equatorial Orbit	When the satellite rotates in an orbits directly above the equator, usually in a circular path.
Polar Orbit	When the satellite rotates in a path that takes it over the north and south poles in an orbit perpendicular to the equatorial plane.
Station Keeping	The process of maneuvering a satellite within a preassigned window is called?
Arthur C. Clarke	He first suggested its existence in 1945 and proposed its use for communication satellite.
Antenna Look Angles	Azimuth angle and elevation angle are jointly referred to as the?
Subsatellite Point	The location that is identified by a point on the surface of the earth, it has no latitude and longitude is called?
Angle of Elevation	It is the vertical angle formed between the direction of travel of an electromagnetic wave radiated from the earth station antenna pointing directly toward a satellite and the horizontal plane.
Azimuth	It is the horizontal angular distance from a reference direction, either the southern or northernmost point of the horizon.
Azimuth Angle	Is defined as the horizontal pointing angle of an earth station antenna.
Limit of Visibility	Which determine the farthest satellite away that can be seen looking east or west of the earth station longitude?
Spinner	It uses the angular momentum of its spinning body to provide roll and yaw stabilization.

Three-axis Stabilizer	The body remains fixed relative to earth's surface, while an internal subsystem provides roll and yaw stabilization.
<p>The required spatial separation is dependent on the following variables:</p> <ul style="list-style-type: none"> ➤ Beamwidths and side lobe radiation of both earth station and satellite antenna. ➤ RF carrier frequency ➤ Encoding or modulating technique used ➤ Acceptance limits of interference ➤ Transmit carrier power 	
Footprint	The geographic representation of a satellite antenna's radiation pattern is called?
Effective Isotropic Radiated Power (EIRP)	The effective power transmitted is called?
Spot beam	They concentrate their power to very small geographic areas and therefore typically have proportionately higher EIRP than those targeting much larger area because a given output power can be more concentrated.
Hemispherical Downlink	An antenna typically target up to 20% of the earth's surface and therefore, have EIRP that are 3dB or 50% lower than those transmitted by spot beams that typically cover only 10% of the earth's surface.
Frequency Reuse	The different beams of the same frequency can be directed to different geographical area of the earth.
Dual Polarization	The different information signals can be transmitted to different earth station receivers using the same band of frequency simply by orienting their electromagnetic polarizations in an orthogonal manner.
High-Power Amplifiers	It is used in earth station transmitters and the traveling-wave tubes typically used in satellite transponders.
Back-off loss	The amount the output level is backed off from rated level is equivalent to a loss and is appropriately called?
Saturated output power	The output power of a typical satellite earth station transmitter is much higher than the output power from terrestrial microwave power amplifiers.

CHAPTER 26: SATELLITE MULTIPLE ACCESSING ARRANGEMENTS

TERMS	DEFINITIONS
Multiple Accessing	<p>Also called as Multiple Destination, It implies that more than one user has access to one or more radio channels within a satellite communications channel.</p> <p><u>Multiple Accessing Arrangement:</u></p> <ul style="list-style-type: none"> • Frequency-division multiple accessing (FDMA) • Time-division multiple accessing (TDMA) • Code-division multiple accessing (CDMA)
Pre-assignment(dedicated)	A given number of the available voice-band channels from each earth station are assigned a dedicated destination.
Demand Assignment	Voice channels are assigned on an as-needed basis.
Frequency Reuse	The method of assigning adjacent channels different electromagnetic polarizations and is possible by using orthogonal polarization and spacing adjacent channels 20 MHz apart.
Anik	Eskimo word meaning "little brother".
Anik-E communications Satellite	Domestic Satellites operated by Telsat Canada.
FDMA	A method of multiple accessing where a given RF bandwidth is divided into smaller frequency bands.
Fixed-Assignment, Multiple Access (FAMA)	Multiple channels per carrier formats assigned and remain fixed for a long Period of time.
Demand-Assignment Multiple Access	Assigning carrier frequency on temporary basis using a statistical assignment process.

SPADE	An acronym for Single-channel-per-carrier PCM multiple Access Demand-assignment Equipment.
SCPC	Stands for Single-Carrier-Per-Channel.
Common Signaling Channel (CSC)	A time division-multiplexed transmission that is frequency division multiplexed.
TDMA	The predominant Multiple-access method of time-division multiplexing digitally modulated carriers between participating earth stations within a satellite network through a common satellite transponder.
Transponder	An RF-to-RF repeater that simply receives the earth station transmissions, amplifies them, and then re-transmits them in a downlink beam that is received by all other participating station.
Reference Burst	It is where transmissions from all earth stations are synchronized.
Carrier Recovery Sequence (CRS)	It is where all receiving stations recover a frequency and phase coherent carrier for PSK demodulation
CEPT	An acronym for Conference of European Postal and Telecommunications Administrations, is commonly used TDMA frame format for digital satellite system
Code-Division Multiple Access (CDMA)	Sometimes referred to as Spread-Spectrum Multiple entire allocated bandwidth Access, the transmissions can spread throughout
Chip Code	A unique binary word that each earth station's transmissions are encoded.

Correlator	It compares two signals and recovers the original data.
Digital non interpolated Interface	It assigns an individual terrestrial channel (TC) to a particular satellite channel (SC) for the duration of the call.
Digital Speech Interpolated Interface	It assigns a terrestrial channel to a satellite channel only when speech energy is present on the TC.
Time-Assignment Speech Interpolation (TASI)	A form of analog channel compression that has been used for sub oceanic cables for many years.
Navigation	The art or science of plotting, ascertaining or directing the course of movements, in other words, knowing where you are and being able to find your way around.
Wandering	It is the most ancient and rudimentary method of navigation and simply continuing to travel about until you reach your destination, assuming of course that you have one.
Celestial Navigation	Earliest effective means of navigation wherein direction and distance are determined from precisely timed sightings of celestial bodies, including the stars and moon.
Piloting	Method of navigation by means of fixing a position and direction with respect to familiar, significant landmarks such as railroad tracks, water towers, barns, mountains and bodies of water.
Dead Reckoning	A navigation technique that determines position by extrapolating a series of measured velocity increments.
Dead	The term derived from the word “deduced” and not necessarily from the fate of the people who used the technique.
Charles Lindbergh	

	He used dead reckoning successfully in 1927 during his historic 33-hour transatlantic journey.
Amelia Earhart	She attempted to make the first around-the-world in 1937 using the dead reckoning technique.
Radio Navigation	Navigation technique wherein the position is determined by measuring the travel time of an electromagnetic wave as it moves from a transmitter to a receiver.
Decca	A radio Navigation system for terrestrial surface broadcast.
Omega	Radio Navigation system that provides global coverage and terrestrial surface broadcast.
LORAN	Also a terrestrial surface broadcast.
Navy Transit GPS	Low-orbit satellite broadcast provides global coverage.
Navstar GPS	Medium-orbit satellite broadcast also provides global coverage.
LORAN	Means of radio navigation in which receivers acquire coded signals from two pairs of high-powered, land based transmitters whose locations are precisely known.
Navstar	An acronym for Navigation System with Time and Ranging.
GPS	An abbreviation for Global Positioning System. <u>Two levels of service or accuracy:</u> <ul style="list-style-type: none"> • Standard Positioning Service • Precise Positioning Service
Navstar GPS	A satellite-based open navigation system which simply means that it is available to anyone equipped with a GPS receiver. <u>Consists of three segments:</u>

	<ul style="list-style-type: none"> • a space segment • a ground control segment • user segment
April 27, 1995	It is when the Navstar was declared as fully operational by the U.S. Air Force Space Command.
Navstar Satellite System	It was completed in 1994 and is maintained by the United States Air Force.
Standard Positioning Service	A positioning and timing service that is available to all GPS users on a continuous, worldwide basis with no direct change.
Satellite Segment	Sometimes called Space Segment, consists of 24 operational satellites revolving around Earth in six orbital planes approximately 60° apart with four satellites in each plane.
Cesium Atomic Clock	It produces highly accurate timing signals for satellites.
Pseudorandom Noise (PRN) Code Number	A unique integer number that is used to encrypt the signal from that satellite.
Ephemeris	A term associated with a table showing the position of a heavenly body on a number dates in a regular sequence, in essence, an astronomical almanac.
Clock Bias Error	Error in the receiver's clock which affects the accuracy of the time-difference measurement.
Operational Control System	<p>The Navstar control segment. <u>It consists of :</u></p> <ul style="list-style-type: none"> • Fixed-location ground based monitor stations • Master Control Station • uplink transmitter
Differential GPS	It makes standard GPS more accurate. It works by canceling out most of the natural and man-made errors that creep into normal GPS measurements.

